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ART. XV.—*On the nature and duration of the discharge of a Leyden jar connected with an induction coil;* by OGDEN N. ROOD, Professor of Physics in Columbia College.

[Read before the National Academy of Sciences, August, 1867.]

PART 1ST.

WHEN the terminal wires of an induction coil of sufficient size are connected with the exterior and inner coating of a Leyden jar, it is well known that the act of breaking the primary current charges the jar with electricity, and that a discharge will take place if the distance between the electrodes is not too great, otherwise the union of the two electricities is effected backward in the coil itself. The brightness of the light, and the ease with which it is generated, render it the most convenient means in our possession for the production of a nearly instantaneous illumination, while its richness in the violet and ultra-violet rays, make it suitable for experiments on fluorescence and phosphorescence. Before, however, it can become useful for these and other delicate investigations, involving the appreciation of minute intervals of time, it is of course necessary that the nature and duration of the discharge itself should be studied, a matter which, so far as I know, has thus far not received attention.

The case of a jar charged by an ordinary frictional machine is quite different from the above: here, during the the act of charging and discharging, the two metallic coatings of the jar are entirely insulated, while when the induction coil is used in

the manner above indicated, these coatings are during both acts in metallic connection, a circumstance which alone might be supposed to modify the duration of the discharge and its nature; besides this, it is known that the electricity from the coil continues to flow for a considerable fraction of a second along the terminal wires into the jar, which fact renders it questionable whether the duration of the discharge of the jar itself may not be proportionately lengthened. Hence it is evident that it would not be safe to conclude without experiment, that the results obtained by Feddersen with jars charged by ordinary frictional electricity, were applicable to those connected with an induction coil.

Historical.—In the year 1835, Wheatstone published in the Philosophical Transactions, part II, page 583, an account of his celebrated experiment on the duration of the discharge of a Leyden jar charged by a common frictional machine. The light from the spark was received directly on a plane mirror revolving at rates between 30 and 800 times in a second; the mirror was driven by a set of multiplying wheels connected *by strings.* This apparatus was constructed by Mr. Saxton of Washington, who at that time was residing in London. The eye of the observer was placed near the mirror, and as the image of the spark was not sensibly drawn out by the rotation of the mirror, Wheatstone concluded that its duration was less than the one millionth of a second, a result which was accepted by the scientific world for about a quarter of a century, passing unquestioned till the publication in 1858 of the first of an admirable series of investigations of this subject by Feddersen; (Pogg. Annalen, Bd. 103, seite 69.) This physicist employed a concave mirror with a radius of half a meter, driven by a train of *toothed wheels,* and obtained as high a rate of rotation as one hundred per second; the spark was generated in one of the conjugate foci of the mirror, and its image, formed at the other conjugate focus on a plate of ground glass, was in a condition to be conveniently seen and measured by the naked eye or to be photographed. It was found that the image of the spark was drawn out by the revolving mirror into a whitish streak, from 20 to 30 millimeters long, which when a large amount of electricity was employed, was still farther lengthened by the addition of a red tail of about the same dimensions, this latter being due to the gradual cooling of the heated particles. With a jar of 2·2 feet inner coating, the distance of the copper balls which served as electrodes being 1·5 millimeters, and all the connections as short as possible, the duration of the discharge exclusive of the red tail was ·00004 of a second. It was also

found by him, that an increase in the size of the coating of the jar or of the "striking distance," prolonged the duration of the discharge; so, for example with a spark 3·75 millimeters long, the duration of the whitish portion was ·00007 of a second.

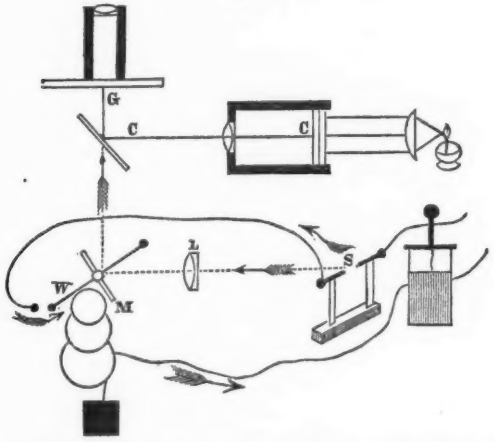
A series of observations detailed at the end of this article, will point out a probable explanation of the great discrepancy existing between the results of Feddersen, which are undoubtedly correct, and those of Wheatstone. Finally, Feddersen in the course of his investigation found abundant proof of the oscillatory nature of the electric discharge, which had been predicted from the results of a set of experiments by Prof. Joseph Henry as far back as 1842.

Apparatus.—I arranged in the first place an apparatus like that of Feddersen, but it was soon found that to attain a rotation of one hundred per second, it was necessary in my case to employ a weight of 200 pounds, and in addition when using this form, I labored under the disadvantage of not being able to vary the size or curvature of the mirror readily; in short it was found to lack *flexibility*, a quality more necessary in the present case than in the investigation which engaged the attention of the German physicist. On this account I decided to employ a plane revolving mirror with a stationary achromatic lens. The addition of an extra wheel, with a few other mechanical changes, converted the train of wheels furnished by Duboscq for Becquerel's phosphoroscope, into an admirable means for driving the revolving mirror, and with a weight of 30 pounds, 300 rotations per second were readily obtained, the motion being smooth and sufficiently uniform. In order to measure the rate of rotation, the cylinder on the lowest wheel was made to wind up a fillet of paper, upon which dots were made by an electro-magnetic apparatus regulated by a seconds pendulum, when a simple calculation furnished the rate of the wheel to which the mirror was attached. By this method it became possible to put to a sharp test the regularity of the rate of the train, which was found in all cases to be considerably greater than was at all necessary. These determinations were afterwards made with a watch having large second spaces, the dots being made by hand, as the refinement of a seconds pendulum and battery was found for my purpose to be superfluous.

The mirrors employed were always plane, being sometimes silvered at the back, while for the most delicate observations the rear surface was painted with black varnish, so as to destroy the second reflection. They varied in size from 1·5 inches square, down to ·2 by ·5 in., and were used sometimes double on the axis back to back, and at other times four mirrors were em-

ployed together. The arrangement is seen in figure 1. The light diverging from S, was received by an achromatic lens L, of nine inches focal length; it then fell on the plane mirror at M, and was finally brought to a focus on the plain or ground glass at G, which was distant from the mirror about 16 inches.

1.



For the purpose of measuring the extent to which the image of the spark had been drawn out by the motion of the mirror, a scale consisting of bright lines on a dark ground, was projected on the ground glass, as seen in the figure at CC, the flame of a small lamp furnishing the illumination. The spark was generated between the balls or wires of a spark-micrometer, graduated in millimeters; this was placed of course in one of the conjugate foci of the achromatic lens. An automatic arrangement for breaking the circuit from three to six times in a second, was employed, mercury and alcohol being used in it. The coil was a large one by Ritchie of Boston; it was excited during these experiments by two cups of the Bunsen form; the simple sparks furnished by it did not at the time exceed seven inches in length. The Leyden jar had a coating of 114·4 square inches, and all the connections were made as short as possible, so as to offer the least amount of resistance to the flow of the electricity. The experiments were usually made in a room not *entirely* darkened, as in a perfectly dark room it was found difficult to preserve the proper "accommodation" of the eyes.

If no means are employed to regulate the moment at which the discharge takes place, it is evident that images of the spark

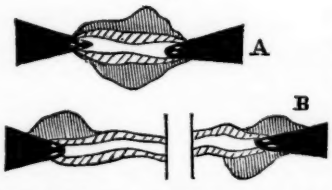
will be thrown on the ground glass only when the mirror happens to be in a favorable position, still as several of them occurred in a second, and as the mirror was always double it did not very often happen the weight ran entirely down before a single observation had been made. I selected a certain portion of the ground glass along the line of images, and exclusively fixed the attention on it, and disregarding the images formed in its neighborhood waited for their appearance in this locality. If the precaution be neglected, much time will be wasted in accumulating observations of comparatively little value. With velocities up to 223 per second, I succeeded in causing the discharge to take place when the mirror was in the proper position, by attaching to its axis a brass wire W, which was made to complete the connection between the exterior and inner coatings of the jar. The arrangement is seen in figure 1, and it was found quite valuable in facilitating *the use of the eye-pieces*, which were employed to magnify the lengthened images of the spark, or to examine the micrometer described at the end of this article. I had been apprehensive that this plan would not answer, as it evidently assumes that the jar remains charged a fraction of a second before it discharges itself backward through the coil.

Appearance presented by the spark, viewed with the stationary mirror.

(*a*) *With brass balls as electrodes.* Here the spark presented its ordinary well known appearance, being merely magnified by the eye-piece.

(*b*) *With pointed wires as electrodes.* When the "striking distance" was one millimeter, the form was that represented in figure 2 at A, viz: a central white portion surrounded by a yellowish envelop, which in the figure is shown by the coarse shading; the second envelop more densely shaded, being green and much inferior in brightness. With a "striking distance" of ten millimeters, the green envelop was produced only in the neighborhood of the electrodes. (see B, fig. 2.) In both cases a number of brilliant minute jets of white light were seen to issue from the electrodes; these are only partially shown in the figures. The green color was due to the heated particles of metal, and the bright points of light to successive discharges, as will be shown farther on.

2.

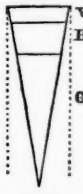


(*c*) *With fine platinum wires.* The appearance was the same as the last, except that the green tint was replaced by a grey or violet-grey hue. These observations were made with a mirror of plane glass, the rear side being blackened, which reduced the intensity of the light adequately for the purposes of distinct vision. The ground glass was replaced by a polished plate, which supported an eye-piece magnifying five diameters.

Appearance presented by the revolving mirror.

(*a*) *With brass balls as electrodes.* With a "striking distance" of one or two millimeters, the image being thrown on the ground glass and viewed by the naked eye, it was found that the spark was drawn out into a streak one and a half or two inches long, according to the rate of the mirror; the portion at W, (fig. 3) was white; this shaded into a brownish yellow tint, (B Y) the latter passing into a pretty distinct green, (G.) It will be found by comparison that this result is exactly that obtained by Feddersen with frictional electricity, except that in my case the green color of the tail seems to have been much stronger, which is explained by the lower intensity of the illumination.

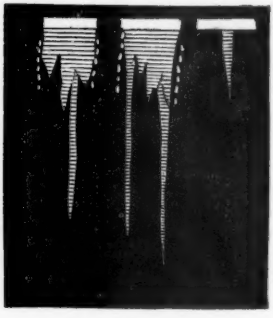
3.



With the unaided eye and ground glass, nothing additional of a remarkable character could be discerned, but on using the polished plate of glass and an eye-piece magnifying five diameters, a series of bright dots on each side of the streak became visible in the positions indicated by the dots in figure 3. These resemble the photographs obtained by Feddersen with frictional electricity. Here it is seen that the bright points bebefore spoken of, correspond to a series of discharges following the first.

(*b*) *With platinum points.* Using the ground glass, I found that the form of the streak was some times identical with that produced from brass balls, the green color merely being replaced by a violet-grayish tint. The form, however, was more often quite different, as shown in figure 4, the change in shape being due to the partial suppression of the tail, and to its irregular production; with low velocities the shape was often as in the smallest of the three sketches.

4.



With eye-piece, polished glass and high velocities, the series of bright points was seen beautifully developed.

(*c*) *With brass points*, this same figure was produced, yet not quite so distinctly. The tail was of course green.

Total duration of the discharge.

(*a*) *Using brass balls.*

Rate of rotation per second.	Number of observations.	Distance of electrodes in millimeters.	Duration in seconds.
109·	6	3	·000050
291·	5	2	·000028
294·	9	1	·000017
120·	6	1	·000030
30·	8	1	·000023
110·	15	1	·000022

No red tail was ever observed in my experiments, the amount of electricity employed not being sufficient for its production. The difference in these observations arises partly from the faintness of the terminal portion of the tail, and also from the fact that its length is a little variable even in discharges following each other in quick succession. Still on the whole, these results correspond pretty well with those obtained by Feddersen, when it is remembered that the coating of the jar employed by me, was less than one half the size of that used by him, which, as well as shortening the "striking distance," tends to lessen the duration of the discharge as proved by his observations.

(*b*) *Using brass points.*

Rate of rotation per second.	No. of observations.	Distance of electrodes in millimeters.	Duration in seconds.
100	10	1	·000025
48	10	1	·000028

(*c*) *When platinum points* were used as electrodes, with a striking distance of three millimeters, the duration, as obtained, varied between ·00004 and ·00014 of a second: the variation seems to be owing to the faintness and narrowness of the tail, which rendered observation difficult and rather uncertain.

Duration of the white and yellow portion.

As it had all along been evident that the main illuminating power of the spark was concentrated in the first explosive act, I made still further efforts to determine the duration of the white and yellow portion of the discharge. The image of the spark, using platinum wires as electrodes with a striking distance of five millimeters, was thrown on the ground glass, a set of observations being made with the naked eye, and also with the aid of the magnifying lens. The color was found to be rather brownish-yellow, shading off and becoming fainter in illumination toward its farther boundary. This yellow flame-

like portion was not nearly so bright as the white band, the latter being to all appearance unaffected by the motion of the mirror. The appearance was that indicated in figure 4, the farther boundary *resembling the irregular outline and color of a burning splinter of wood.*

The duration was found to vary from

·000003
·000007

of a second. The rate of rotation was 206 per second. Determinations of this same point had previously been made at an early stage of the work; their result was

·000008
·000006

of a second. There can be no doubt but that the duration of the yellow portion in individual sparks varies within limits like the above as can be seen by a comparison of successive discharges.

Duration of the white band.—Up to this time I had been able to obtain no evidence that the duration of the white band was other than instantaneous, indeed with this mode of experimenting the contrary cannot be proved. The preceding analysis had shown that a large portion of the light of the spark resided in this white band, i. e., in the first discharge, and when points were used as electrodes its superior brightness to some extent isolated it from the rest of the streak. To ascertain whether it was to be regarded as a separate act by itself, or as only the beginning of a continuous action lasting ·000005 of a second or longer, I made the following simple experiment: instead of receiving the light of the spark directly on the achromatic lens L, it was used to illuminate a strip of white paper ·14 of an inch in breadth; this was placed horizontally, the direct light from the spark being prevented from reaching the lens by a screen. The "striking distance" was 1·3 millimeters. With low rates of rotation, the appearance of the image of the band *viewed by an eye-piece* magnifying five diameters, was quite unaltered; as the rates of rotation were increased the illumination of the image of the band grew fainter, but with the highest velocity, 223 per second, it was *distinctly visible and of the same breadth*, as far as could be ascertained by the use of the micrometer. This proves of course that the first discharge is a simple act, and isolated from those that follow. Next, as an appropriate termination to this experiment, I blackened all the surface of the strip of white paper except so much as served to form a square. On examining the image of this with the same rate of rotation, the square was tolerably

visible: it was followed by a faint flame-shaped tail, corresponding to the yellowish portion of the discharge.

Having thus proved the existence of an isolated discharge, at once the first and most brilliant act in the explosion, a method was contrived for measuring its duration, or at all events for setting a limit to it on at least one side. Ordinary micrometric methods, conducted on the naked spark or on a strip of paper illuminated by it, were out of the question, and would have served no purpose except to lead the observer into error, so I contrived the following plan, which is moderately easy of application and safe.

A small piece of cardboard was ruled with two black lines; their distance apart was ·0067 inches, and they were separated by a space exactly equal to the width of a single line. A small dividing engine was used for their production; they were tested with a microscope. These lines were illuminated by the spark, and their image examined by an eye-piece magnifying five diameters. The breadth of the image of a single line on the ground glass was ·011 inches, that is, each line subtended an angle of 2′ 24″, reckoning from the mirror. With a velocity of 223 per second the mirror is able to move the reflected image through 2′ 24″ in the ·00000024 of a second. If now this first discharge had actually lasted this minute portion of time, it is evident that the motion of the mirror would just have carried the image of one of the black lines forward, so that at the end of this infinitesimal period, it would have occupied the space where just before the white line had been traced: hence owing to the retention of impressions by the retina the white central line would have been obliterated, and in place of three lines, a gray band would have been seen. On the other hand if the duration had been only $\frac{1}{10}$ or $\frac{1}{3}$ of the above mentioned interval, the white line not having been much encroached on, would still have remained visible. The correctness of the above reasoning can be experimentally proved, by means of a revolving disc of card board with a single slit cut in it, lines being drawn on its white side, and viewed by reflection with a mirror through the slit, the blackened side of the disc being turned toward the eye.

To facilitate matters, *three sets* of these lines were drawn on the small cardboard at considerable distances apart to prevent confusion, and while illuminated by the electric spark were examined with increasing velocities. With low rates they were quite unchanged in appearance, with a velocity as high as 102 per second, a duration of the first discharge of ·00000052 seconds would just have obliterated them; they were however perfectly distinct, though more faintly traced: the rate of ro-

tation was then by degrees carried up to 223 per second, when the lines were still distinctly visible, though of course with less contrast between the white and black, than was the case with low velocities or a stationary mirror.

This experiment proves then, that the duration of the light accompanying the first discharge is considerably less than ·00000024 of a second, probably less than half this period, or less than one ten millionth of a second of time. To make the observations required some patience, as it was necessary to use an eye-piece, the ground glass being replaced by a plain polished plate, and it was seldom that the image of the lines fell exactly in that portion of the field to which the attention was directed. To obviate this difficulty, I afterward *covered* a piece of cardboard half an inch broad with alternate white and black lines of this character, their real diameter was ·0075 in., that on the plate of glass being ·0125 in. With these I repeated the above mentioned set of experiments with rapidity, obtaining with ease the same result, as some of the lines were almost certain to be in the right part of the field of view. It is thus shown, that the first act of the electric explosion lasted through an interval of time so short as to be immeasurable with the means then at my disposal; it is not impossible that it may still be reached by the use of finer lines, and a lens of greater focal length.

From the foregoing then it appears that if a jar having a metallic coating of about 100 square inches, be connected as above described with an induction coil, its discharge will be effected by a considerable number of acts, of which the first is by far the most intense. Farther, the metallic particles heated up by the first discharge to a white heat, almost instantly assume a lower temperature, marked by a corresponding change from white to brownish yellow, and as their temperature continues to fall the tint changes in the case of brass electrodes to green, in that of platinum to a gray or violet-gray. A spectroscopic examination of these isolated tints would be interesting but not without difficulty. These observations farther demonstrated the fact, that two ten millionths of a second is an interval of time quite sufficient for the production of distinct vision.

When the light from the spark is received directly on a plane revolving mirror, and viewed by the eye as in Wheatstone's original experiment, only the white unanalyzed portion of the spark is ordinarily visible; at least in repeating the experiment a few times, it is all that I saw. Its form is of course

that of the spark itself. In all probability this is also the case in a jar charged by frictional electricity, and may serve to explain the great discordance between the results obtained by Wheatstone and Feddersen, the method used by the former furnishing only a view of the first act, the eye being too much dazzled to perceive those that are subsequent and of far less intensity.

ART. XVI.—*The Star-Mapper;* by HENRY M. PARKHURST.

EARLY in the year 1856, I commenced the construction of a star-mapper, designed to extend the principle of the Chronograph, which maps right ascension only, to an instrument mapping both right ascension and declination. On the 7th of October, 1856, having completed with my own hands the necessary apparatus, I took my first map.

In my first apparatus a concave lens was moved in declination, perpendicular to the axis of the eye-piece, the telescope being fixed in the meridian and the stars as they crossed the field of view were thus optically brought in succession to the crossing of two fixed illuminated wires. A few levers converted this motion into a horizontal motion of the marking point or star-key, at right angles with the motion of a roll of telegraph paper one inch wide carried by a clock movement. Striking the star-key, at the instant of the transit at the center of the field, mapped the star in its proper position. In order to take a map several degrees in width, I omitted the concave lens and moved the telescope itself in declination, with a slightly varied system of levers.

So far there was no difficulty. But a star-mapper which would only map in the meridian would have been to me valueless; and I reconstructed and rearranged very many times the system of levers by which I could convert the visible motion at any desired parallactic angle into a horizontal motion of the star-key. My experience in the fall of 1856 convinced me that my apparatus had two radical defects.

1. The motion of the telescope to obtain the declination was troublesome, even for a 3-foot telescope, owing to the necessity of overcoming at every star the inertia and momentum of the whole telescope, and the consequent inaccuracy; and it would have been impossible with my means to mount my 8-foot telescope, which I procured the following year, with such accuracy as to make this method of mapping possible. And further, when the telescope is clamped we have twice the ini-

tial motion with the same field, and the error from any mechanical inaccuracy is therefore proportionally less.

2. Several of my early plans involved the motion of the star to a fixed point in the field. I abandoned this, substituting the motion of the point to the star, for two reasons.

(1.) It required a continual motion of the eye-piece, (or telescope,) to bring within the field the stars to be mapped; for while mapping a northern star, a southern star which ought to be mapped would be outside of the field.

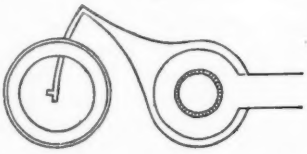
(2.) It brought within the field twice as many stars as I desired to map, with no line of demarcation between them.

In 1860, thinking that I had worked with my pine mappers and narrow paper long enough, the instrument being readily adjustible and convenient for mapping in any desired position, I procured my first permanent star-mapper, chiefly of brass, adapted to map 90′ in declination upon the scale of the Chacornac charts. In 1863, desiring to make charts upon twice that scale, I had another and larger mapper constructed, varying only in unimportant details. This latter instrument I will proceed to describe.

A large diagonal prism placed in the meridian inverts the image in declination, bringing the north point to the top of the field, the stars moving toward the left. Then if I wish to map in the eastern sky, I turn the prism to the left upon the axis of the telescope, and turn the field-piece with its attachments the same angle upon its own axis, also to the left, the angle being such as will be most convenient to the eye, the plane of the field making an angle of about 60° with the horizontal plane.

Figure 1 represents the plane of the field of view. In the center of the field of view is represented the star-point, by which the stars are to be successively occultated, there being a projection upon the left, easily seen in the absence of illumination, to mark the exact point of occultation. This star-point describes an arc, the center of motion being represented to the right, outside of the field of view, and being firmly supported by the field-piece. The line connecting the center of motion with the center of the field is parallel to the apparent motion of the stars. Into the field piece is fitted a positive eye-piece of suitable magnifying power.

1.

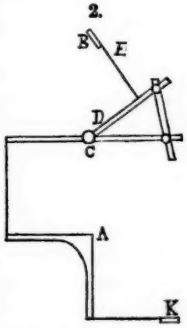


The arc described by the star-point is exactly equal to that described by the star-key; and the levers connecting the two are so adjusted that moving the star-key across the width of

the map shall exactly carry the star-point across the field of view. Unless it is desired to record the right ascension of the stars by the chronograph simultaneously with the mapping, it is better thus to map in corresponding curves than to provide means, as I did in my early apparatus, for moving both the star-key and star-point in straight lines.

The star-point receives its motion from a star-point-bar, which turns upon the same center of motion. A circular disk two inches in diameter, carrying the star-point, is clamped to a similar disk on the left end of the star-point-bar, as represented, at such an angle that the bar shall be horizontal when the star-point is in the center of the field.

The star-mapper must next be adjusted at a convenient height and distance, so that the arm of the star-key, when in the center of the map, shall be parallel to the star-point-bar. Fig. 2 represents the connecting levers, as seen from the left. K represents a cross section of the further end of the arm of the star-key, playing, as thus seen, horizontally to the right and left. It is connected by a rod with a universal joint at each end, to the right-angled lever pivoted at A. A perpendicular rod adjustible in length communicates the motion to a horizontal lever, whose center C may be adjusted in height. Turning on the same center C is a bar D, which communicates the motion through a rod E, of variable length, with universal points, to the star-point-bar B, previously adjusted, a cross section of the further end of which is represented in the figure. The angle of the bar D to the horizontal bar may be adjusted by a clamp upon the connecting bar. By the adjustment of this angle, and of the position of the mapper, the connecting rod E must be brought into the plane of the motion of the bars B and D, and at right angles with them.



All these adjustments having been properly made, when the star-key is at the center of the map each connecting rod will be in the plane of the motion of each bar with which it is connected, and at right angles therewith ; and these rods being of suitable length, moving the star-key will not vary these relative positions so far as to produce any important want of uniformity of motion of the star-point. The adjustment of the rate of motion of the star-point may be most conveniently made, either by varying the effective length of the bar B, or of the bar D, or both.

As an illustration of the ease with which the apparatus may be adjusted with sufficient accuracy for the identification of the stars, I will state that I have found it easy to take a succession of twelve 15-minute maps, in selected places varying many degrees in right-ascension and declination, in but little over three hours.

The minor details, such as the mode of supporting the various centers of motion, the mode of securing the requisite ease and accuracy of motion at the various centers without lateral motion, the mode of securing the proper motion of the paper, the mode of making the universal joints, &c., may be varied according to the desired accuracy and the allowable expensiveness of the apparatus.

Some of these details it may be well, however, to refer to more particularly.

The perpendicular arm of the right-angled lever A is of board about nine inches wide, connected at the left end with the star-key and at the right end with the levers C D, answering three purposes: 1st, it carries the star-key nine inches to the left, bringing it into a more convenient position in relation to the eye-piece; 2d, lateral motion is obviated by placing the pivots at A, nine inches apart; 3d, this arrangement protects the clock movement, which is immediately in front of this board and beneath the solid framework supporting the pivots. The clock-pendulum is supported by the stout bar which supports the center C.

It is important that lateral motion should also be guarded against at the center C, and at the center of motion of the star-point-bar, shown in figure 1. Each of these centers is therefore constructed with pivots sufficiently separated to accomplish that object. The ends of the rod E are connected with slides clamped upon the respective bars B and D, so as to be easily varied in adjusting the rate of motion of the star-point. The simplest mode of making a universal joint, and that which I have therefore adopted in my own mapper, is bending the ends of two wires snugly around each other.

The arm of the star-key K moves horizontally, and is pivoted opposite the center of the paper, to the left, describing an arc exactly equal to that described by the star-point, but of about three times the radius. It strikes an adjustible stop on each side by which the width of the map is limited. The star-key itself I have used in many different forms. The only form which has been satisfactory, although not constructed with such perfection as I should desire, is the following:

The star-key is compound, consisting of a series of eight vertical keys or manuals, either of which may be used at

pleasure to impress the paper. These manuals are enclosed in a cylindrical box, and the series may be revolved horizontally by turning the knob on the top of the box, a projecting pin indicating by its direction which of the keys is to the right hand. This pin having been turned as desired, pressing on the knob, locks the plate holding the series of manuals from further horizontal rotary motion, and depresses the manuals so that they nearly touch the paper. The outside casing is cut away above the manual to the right, so that at the proper instant that may be struck by the finger to impress the paper in the proper position.

Not only are the several manuals thus interchangeable, by the rotation of the series, but each of the eight manuals may be turned upon its own axis. Thus, that with which I indicate the 10th to the 13th magnitude, impresses upon the paper a short dash like a hyphen, pointing in any required direction; the horizontal dash indicating the 10th magnitude, and a revolution of 45° being allowed for each lower magnitude. The brighter stars are indicated by more conspicuous forms; and there are special marks for double stars, clusters, nebulæ, &c. The approximate form of the impression upon the paper is given to the top of the manual, so that any error in bringing the wrong manual to the right, would be instantly detected and rectified before impressing the paper.

The star-maps thus impressed, if the paper is of good quality, do not need inking; but I have marked with pencils and ink of different colors, such stars as I have recognized upon two or more than two maps, in order that any new stars might be conspicuous from their remaining unmarked.

I have used paper cut in strips of the proper width and wound upon a roller at the left of the star-key and beneath the arm of the star-key. The end is passed between guides and over the mapping cushion, between the rollers which are carried by the clock movement, and then the paper is wound upon another roller, also carried by the clock movement. The gradually increasing size of the roller on which the paper is wound, from the addition of the paper, is compensated for by a spring, which is at first gradually relaxed and afterwards again tightened; but which is sufficiently wound up by a key before commencing to map, to keep the paper always tight.

In the action of the levers of the mapper, arranged as above described, there is a slight theoretical inaccuracy, which, in my own instrument, is sufficiently compensated for by two expedients, but which may be entirely removed by a slight change in the construction. For instance, as described, the motion of the lower end of the arm A is exactly equal to that of K in

the middle of their motion; but moving the arm K, either forward or backward, moves that end of the connecting rod slightly to the left, and at the same time slightly raises the other end. Hence the effective length of the rod will be a little less at the edges of the map than in the center, and the southern portion of the map will be slightly condensed in declination. The same inaccuracy is repeated at the connecting rod E. In the latter case, instead of adjusting the real rod E as described, I adjust an imaginary connecting rod, each end of which is drawn toward the center of the motion of the bar to which it is attached by one-half the versed sine of the arc which that bar describes, thus reducing the inaccuracy to one-fourth. But in the other case I have slightly raised the star-key, and increased the angle of the lever A by an amount equal to the mean angle of depression of the connecting rod, accomplishing the same result. The remaining error from this cause is inappreciable, unless the connecting rod E is extremely and unnecessarily short.

In order entirely to remove this theoretical error, it is only necessary to substitute for those two connecting rods, chains moving at both ends over arcs, and kept constantly tight by springs. The effective portion of each chain will then remain in an invariable position and be of invariable length. With this modification, I believe this construction to be absolutely free from theoretic inaccuracy; and I believe it to be the only apparatus yet devised to record with theoretic accuracy, by mechanical means, the right ascension and declination at the same instant, or in other words, to make a chart of the stars observed, the errors of which shall be entirely errors of observation and inaccuracy in the mechanical construction of the apparatus.

The mode of operation will be readily understood. Removing the cap from the telescope, I take my seat in total darkness, and start the paper. Selecting the first star to be mapped, with my right hand I move the star-key back and forth until the star-point visible in the focus of the eye-piece comes into the same declination with the approaching star. At the same time with my left hand I turn the knob of the star-key until the projecting pin indicates that the desired manual is at the extreme right, where it is accessible. Then pressing down the knob, I properly turn the manual on its axis, with my right hand, and placing my fore-finger upon it, I wait for the occultation of the star opposite the outer edge of the projecting bar upon the star-point. At that instant I tap on the manual and the star is mapped. I then select another star and map it in the same way; and so on, at a rate varying from

two or three to thirty per minute, and averaging nearly 500 stars per hour. When several stars present themselves almost at the same instant, I have preferred, rather than to omit any of them, to divide the error of right ascension and to map them as rapidly as possible. Usually by predetermining the order of mapping, I can map six or eight stars in quick succession, without an error exceeding two seconds. When the paper reaches the end, a spring constantly pressing upon it, locks into the star-key, and thus indicates the conclusion of the map.

It may not be improper for me to add briefly my reasons for not having before described my invention in the columns of any scientific journal. I wrote at an early day a general account of my apparatus to various astronomers, among whom were Dr. Gould, Dr. Bache, and Prof. Mitchell, who was then at the Dudley Observatory; but I desired to give a practical illustration of its utility in the discovery of a new asteroid. On Sept. 30th, 1862, I announced by a printed circular, my discovery of a new asteroid, "by the aid of my star-mapper," and briefly stated in that circular the history of my invention. My discovery of Galatea was announced in the next number of this Journal, (page 430), Mr. Tempel's prior discovery being yet unknown in the United States. On the 18th of October, the director of the Dudley Observatory called upon me and saw my apparatus and maps, and they were afterwards shown by me to Dr. Gould, Mr. Rutherfurd, and others who were interested in astronomy. But at that time I had devised an apparatus by which not only the exact places but the measured magnitudes of the stars observed should be recorded; and I decided to defer the publication of the description of the star-mapper until I should be able to publish in connection with it a description of my Photo-mapper. With your permission, I will, in your next number, proceed to describe this latter instrument.

ART. XVII.—*Additional remarks on the Nineteen-band Test-plate of Nobert;* by J. J. WOODWARD, Asst. Surgeon and Brevet Lieut.-Colonel U. S. Army. Contributed by permission of the Surgeon General.

IN a former paper in this Journal (II, vol. xlvi, page 352) I gave an account of certain observations made on the new nineteen-band test plate of Nobert with various lenses. The general result of these observations was, that, with the $\frac{1}{25}$th

of Powell and Lealand, with which lens I secured the best definition, the lines of the fifteenth band were distinctly resolved. In the higher bands spurious lines, fewer in number than the real ones, were seen. The nature of these lines was conclusively shown by a count. With the paper, I sent to the editors a series of photographs, taken by Brevet Major E. Curtis at the Army Medical Museum, which showed in a satisfactory manner precisely what had been done. Upon the basis of these experiments and photographs, I expressed the opinion, that, those who had previously supposed they had seen the true lines in higher bands than the fifteenth, had been misled by the spurious lines described; an opinion which has been still further strengthened by subsequent experiments with lenses by the maker whose objectives were supposed to have been successful.

During March of the present year I received from Nobert another nineteen-band test-plate made differently from any I have as yet seen in this country. The glass cover measures but the $\frac{1}{275}$th of an inch in thickness, and this is cemented to a glass circle the $\frac{1}{100}$th of an inch thick, supported on a strip of brass. The new plate, therefore, permits the use of lenses of the highest power, and may be illuminated by extremely oblique light or by an achromatic condenser of very short focus.

I found, nevertheless, that the $\frac{1}{25}$th of Powell and Lealand would go no further on this than on the former plate and their $\frac{1}{50}$th gave the same result; it would not resolve the sixteenth band.

With a new immersion $\frac{1}{16}$th, just made for the Museum by these makers, however, I had the satisfaction of distinctly resolving the four refractory bands, and Dr. Curtis has prepared for me photographs of them, which accompany this paper. With the same lens, also, I satisfied myself more positively about the real number of lines in the fifteenth band. The counts I obtained were as follows: fifteenth band 45 lines, sixteenth band 48 lines, seventeenth band 51 lines, eighteenth band 54 lines, nineteenth band 57 lines. The photographs of Dr. Curtis were taken without an eye-piece, and with such a distance that the immersion $\frac{1}{16}$th gave 1,000 diameters. The illumination was by sunlight passed through the ammonio-sulphate of copper, a $\frac{1}{5}$th objective of 148° angle of aperture being used as the condenser, without diaphragm or stop, and obliquity of light obtained by means of the centering screws of the secondary stage.

I send two prints on glass, of which, the first shows the 16th, 17th, and 18th bands, satisfactorily resolved. The second shows satisfactorily the 19th band only. These pictures should

be studied under a power of from two to six diameters. In counting the lines on them some doubt might arise, especially in the case of the 18th and 19th band, as to the real number of lines; for certain spurious lines, which are interference-phenomena, may be seen on the margin of the bands, and it is not always easy to tell which is the last real and which is the first spurious line. A comparison of several glass positives from different negatives with each other, and with the bands as seen in the microscope, where a change of focus materially aids in the determination, has led me to adopt the count above given.

Besides the prints on glass, I send some paper prints enlarged to two thousand diameters. These show the lines very well to the naked eye, but the loss of definition, inevitable in enlarged paper-prints, leaves so little difference in appearance between the real lines, and the spurious ones, on the edges of the bands, that they cannot be used for a count.

On comparing other lenses with the new immersion $\frac{1}{16}$th of Powell and Lealand, thus found to excel so far their dry $\frac{1}{30}$th and $\frac{1}{25}$th, I obtained the following results.

An immersion $\frac{1}{15}$th by Wales resolved the sixteenth band; an immersion $\frac{1}{20}$th by Wales resolved the seventeenth band. The same was done by a Hartnack immersion, No. 11, belonging to Dr. Barnard. A Tolles' immersion $\frac{1}{5}$th, just constructed for Dr. J. C. Rives of this city, resolved the fourteenth band, but failed to go further. I learn also from my friend, Mr. W. S. Sullivant, who received one of the new Nobert's plates on thin glass at the same time as myself, that with an immersion $\frac{1}{6}$th just constructed for him by Mr. Tolles, he also failed to go beyond the fourteenth band. While this paper was being prepared, I received through Mr. Charles Stodder, a new immersion $\frac{1}{16}$th by Tolles, with an angle of aperture of 175°. With this lens, after repeated trials, neither Dr. Curtis nor myself succeeded in seeing the true lines beyond the sixteenth band, and this was not as well shown as the nineteenth band was by the Powell & Lealand lens.

Returning now to this immersion $\frac{1}{16}$th, it may be remarked that the work just done with it has an important bearing on the question of the real limits of microscopic vision. Nobert in sending me the plate above described, wrote me, that in his opinion, the fifteenth band was the limit of possible microscopic vision. He based this opinion upon Fraunhöfer's formula with regard to the spectra of gratings, and upon the known wave length of light undulations. Dr. Barnard of Columbia College, New York, after reading Nobert's letter, writes me that in his opinion, Fraunhöfer's formula does not apply to the

visibility of fine lines when observed with a modern microscope of high power, since the great angle of aperture of the objective permits oblique rays to reach the eye, and Fraunhöfer's formula applies only when the eye is perpendicular to the grating. Dr. Barnard is therefore of the opinion that the limit suggested by Nobert has no real existence. In his letter, which I should mention was written before he was aware that I had satisfactorily resolved any of the bands beyond the fifteenth, he proposed that a trial should be made, to resolve the test-plate with monochromatic light, of colors having longer wave-lengths than the violet which I had been using. Accordingly, obtaining monochromatic light by a prism on which a ray of sunlight was thrown, I succeeded after some trials, in satisfactorily resolving the nineteenth band with each of the colors of the spectrum, from the violet to the red. It may therefore be concluded, that, the present limit to microscopic vision is simply the goodness of the objective, and the rapidity of recent improvements may well lead us to hope for a still further advance.

ART. XVIII.—*On some remarkable relations and characters of the Western Boulder Drift;* by E. ANDREWS, M. D.

THROUGHOUT central Illinois and probably in the corresponding latitude of adjacent States, the ancient Pliocene soil still lies undisturbed beneath the boulder drift. This soil has been met with in excavations at so many independent points, that in its own region it may probably be considered as the usual floor on which the drift rests. Two of the best observations upon it were obtained at Bloomington, Ill. In sinking two coal shafts the workmen first passed through 118 feet of unmodified drift clay, whose boulders and pebbles were all of northern origin and often scratched by the action of ice. Directly beneath this was a bed of ancient soil, on which logs of wood lay scattered confusedly about, and in which the stump of a tree still stood where it grew. Beneath the soil bed lay various sands, gravels and clays, and a second dirt bed, but no more northern drift. The stump was of coniferous wood.

The extensive existence of this preglacial soil has only recently been realized by scientific men, and hence the efforts to restore its fauna have been few, and as yet unsuccessful. Patches of the same formation exist farther north. One has been exposed by the erosion of the waves of Lake Michigan, twelve miles north of Chicago. One has been struck near Beloit, Wisconsin;

another, supposed to be of the same age, lies on the south shore of Lake Huron; and others have been struck by sinking wells at several places both in the northern States and in Canada. Another fact is of considerable interest, as showing how closely the succession of Quaternary formations here follows the relations in Europe, as shown by Mons. Dupont in Belgium. Upon the top of the glacial drift, and separating it from the loess there is another dirt bed, which has been studied mainly at Davenport, Iowa, by the Davenport Academy of Sciences. It appears that at the close of the glacial drift in that region, the waters of the Mississippi subsided within the rock bluffs, and the drift slopes were covered with soil, which showed its atmospheric exposure by the fact that it was guttered to some depth by small streams which cut perpendicularly into it. Over this soil lies the loess often forty feet in depth. The same formation apparently is exposed at Quincy, Ill., and traces of it are seen in other parts of the west. It appears therefore that the fresh-water submergence which deposited the loess was not a continuation of the drift action, but was in this region separated from it by a tranquil period, during which the rivers were down within their banks, and at or near their present levels. The loess at Davenport a short distance above the dirt bed, yielded the skeleton of an *Elephas*, probably *americanus*. The shells found there were all land species so far as yet discovered. The following comparison shows how closely Quaternary events in the Mississippi valley have kept step with those in Europe.

American Section.	*European Section,* (from Dupont's Belgian Excavations.)
Present soil.	Present soil
Loess. Extensive submergence.	Loess. Extensive submergence. Terre a brique of Belgium and France.
Ancient soil, worn by aerial denudation. Streams within their banks. Great Pachyderms alive. Human relics reported but not established.	Ancient soil and land surface. Streams within their banks. Middle river drift of Belgium and France. Great Pachyderms apparently existing. Paleolithic human relics.
Glacial Drift. Rolled stones and boulders derived from the north. No fossils either human or otherwise. Great ice action.	Lower river drift of Belgium and France. Rolled stones and large boulders transported from a distance, in the direction of the river valleys. No human relics. Pachyderm bones abundant. Evidences of ice action.
Pre-glacial soil, probably Pliocene. Fauna not explored.	Pre-glacial soil seen at Norfolk Crag. (Lyell.)

Another characteristic of western drift is that as a whole it is beyond all question a stratified water deposit. There is probably in no part of the world so good an opportunity to settle this disputed point by field observation. The waves of the great lakes eroding their shores keep exposed hundreds of miles

of magnificent drift sections, both modified and unmodified. Besides there are over fifty railroads which have cut the hills in every direction, and innumerable wells, coal shafts, tunnels, and river erosions, making in all probably 2000 linear miles of drift section exposed to observations. It is impossible to mistake the meaning of the facts, and the result has been to oblige those western geologists most familiar with the sections to abandon the glacier theory and admit that the boulder drift of this region is altogether an aqueous deposit, though the waters floated vast quantities of ice.

It has often been stated that the only stratified drift is that which has been rearranged by water since its first deposit. This rule entirely fails in the west, the original drift being clearly stratified. I ought to remark that the distinction between the two is easily made out by the form of the surface. Original drift is marked by a peculiar style of undulation, and by the frequent occurrence of circular and oval valleys without any outlet. Modified drift arranges all its excavations with reference to lines of drainage, and its valleys all have outlets. The eye once educated to these distinctions will rarely commit an error in deciding between the two. Now the stratification, with its beds of clay, sand, gravel, etc., is often just as clear in the original drift as in that which is modified, and even the summits of lofty hills show both stratification and cross stratification in the plainest manner, such as water only can produce. It is true however that there are thick beds of clay and other materials where the lines of lamination are so obscure that they escape attention when penetrated with the pick and the shovel, but even then, they are generally intercalated with well stratified layers of sand and gravel so as to establish the aqueous origin of the whole. These thick and at first glance non-laminated beds almost invariably show their strata when exposed on the lake shores to the erosion of the waves, and of the atmosphere, so that it may be said that a proper study of the boulder drift is impossible to one who neglects to examine the shore bluffs. Perhaps the most remarkable series of facts connected with the western drift is that which indicates the energy of the water action during its deposit. The first of these facts was observed by Prof. Jewell of Chicago, and was published in this Journal. A brief re-statement may be necessary. The city of Chicago pushed a tunnel for two miles in the unmodified boulder clay beneath Lake Michigan for the purpose of drawing water from a point distant from shore contaminations. This clay was stratified in thick beds, and contained two kinds of erratic blocks, viz., boulders of rock and *boulders of loose gravel.* The latter were sometimes three feet

in diameter, and had exactly the shape of ordinary boulders, and terminated abruptly on all sides in the solid clay. In many intances projecting angles near the upper parts overhung their bases, and in general the whole contour was such as was impossible for loose gravel to assume under the mere action of water. Every scientific man that saw them was convinced of two things, viz., that the gravel was dropped from floating ice in frozen masses, and that it was covered up and supported in position by the clay before the frozen masses had time to melt, otherwise the loosened pebbles would have fallen down in conical heaps. An unavoidable, and, at that time, a very perplexing inference was, that in order to support the gravel masses before they melted the clay must have been deposited with enormous and unacountable rapidity; but later observations upon the drift north of us have dispelled the wonder so far as this section is concerned, by showing a still greater violence of water action in the regions from which the clay and the gravel came, as the following facts show.

The state of Wisconsin is channelled with a remarkable valley. Commencing north of Lake Michigan near Lake Superior, this depression runs southwest and contains in its northern part the waters of Green Bay, and in its southern portion those of Rock river. It pursues an almost straight course for 400 miles and terminates at the Mississippi river where Rock river empties into it.

From the northwest, the country descends by a gentle slope into the valley, but from the southeast it breaks down suddenly and often by a perpendicular precipice, as though the rocks on that side had been lifted along the line of a fault. A rocky ridge or rather an elevated region of Silurian rock some 300 feet in height, separates this valley from Lake Michigan, upon which reposes a thick and remarkable drift deposit. The peculiarity of the formation is that it consists of a vast body of very coarse stratified, and well water-worn gravel, which for some distance on the side next the valley is almost pure rolled stone, but as we recede to the southeast becomes mixed with clay, and at a distance of 20 miles gradually shades off into the boulder clay of Illinois, such as contained the gravel boulders above described from Chicago tunnel. This gravel deposit, which is partly described in Lapham's Antiquities of Wisconsin, rises along its central part into a ridge of lofty hills, some of which run up in sharp eminences to over 800 feet above the level of Lake Michigan. The gravel deposit commences on the peninsula between Green Bay and Lake Michigan and runs southwest about two hundred miles, and being over 20 miles in width it covers an area of over four thousand

square miles. The hills are often sharp and conical and interspersed with deep circular valleys without outlets, from which the region has obtained the popular name of "The Potash Kettles." In the northern part the gravel is very coarse, many of the pebbles being more than a foot in diameter, and yet well water worn, and thrown up into steep round hills so lofty as to imply great violence in the water action that threw them up; but as we trace it southward the material becomes finer and the hills lower, until they shade off imperceptibly into the drift clay of the Illinois Prairies. The stratified character of the gravel, though often obscured by the coarseness of the material is on the whole too evident to admit of any possible doubt, as in innumerable places it exhibits both stratification and cross-stratification in the plainest manner. On the opposite or northwest slope of the valley no such gravel formation exists. It would seem to be an unavoidable inference that our drift of this region not only came from the north, but it came in a vast sweep of water deep enough to cover gravel hills more than 800 feet high, and with velocity enough to throw such coarse material into lofty and steep summits. It would appear that the uninterrupted sweep of the waters down the gradual northern slope of the valley allowed no great deposits, but that the current striking the precipice constituting the southern edge, was partly obstructed, and thrown into extraordinary and irregular commotion, piling lofty gravel hills in some places, and leaving deep hollows in others, as it swept across the elevation. The finer materials would be carried onward and settle as clays farther south as we find actually the case. Under such circumstances it is no longer surprising that masses of frozen gravel dropped by icebergs south of the gravel range, were covered with clay before they had time to melt. If any one claims that this gravel range is a lateral moraine of some ancient glacier occupying the Green Bay valley, it is sufficient to answer, first, that the gravel in no manner resembles moraine material, and secondly that such a glacier would have its moraine on both sides, and at the end, whereas the gravel is only on the southeast flank of the valley.

It is interesting to notice that a similar gravel range flanks the southwestern border of the valley of the Georgian Bay, which juts out southeast from Lake Huron. This is described by Rev. Thos. Hurlburt, of Caistorville, Ontario, Canada, in a paper to the Chicago Academy of Sciences, not yet published.

Another fact which shows the aquatic character of our drift agencies, is that the gravel hills, as well as nearly all the other drift of this region are covered with a thin stratum of orange-colored loam, which varies from a few inches to several feet in

thickness, and follows all the undulations of the surface except the valleys of erosion. This loam is free from boulders, and is very plainly stratified. It seems to have been a deposit of quieter water, after the violence of the previous action had expended itself, or perhaps after the rising again of the crest of the Laurentian Hills above the waves had cut off the further progress of both water and floating ice. I am not sure whether this loam covers the very highest summits, but it certainly lies like a blanket over all the lower country up to several hundred feet above the lake, and seems to prove that this region remained for a time under water after the boulders ceased to arrive. That it was not the product of a later submergence cotemporary with the loess, I infer, because I have never been able to discover any trace of black soil between it and the boulder drift, such as would have been found, had there intervened a period of dry land between the two. This loam is found both in the basin of the lakes, and outside of the rim of the latter on all the seaward slopes, except the northern.

If we follow the western drift toward its sources in the far north, we are confronted with still further marks of the violence of the action which transferred it. Rev. T. Hurlburt, whose paper was quoted above and who has been for forty years an acute observer of drift phenomena over the whole region from the Hudson's Bay to the Ohio river, says there is little or no drift material on the north slope of the Laurentian Hills. The whole country is scratched and pounded by the drift action, but the loose material has nearly all been swept southward. Not even the boulders could keep their footing. The only exceptions are where abrupt declivities front north in such positions as to oppose the current. In these cases though the finer materials are gone the boulders are piled up in vast slopes with their surfaces rammed together like a pavement. The soil of the country consists only of vegetable mould resting on the smooth rock. Prof. Dawson of Montreal, whose observations I presume were made in the eastern part of the range, says the region of the Laurentian Hills, though well worn by drift action, is nearly destitute of drift material. He believes fully in the aquatic character of all our drift deposits. Maj. Robert Kennicott, whose arctic journal is now being printed by the Chicago Academy of Sciences, crossed the western part of the range and remarks that the northern slope for hundreds of miles is smooth rock, almost absolutely destitute of any other soil than a few inches of decomposed vegetation. We seem therefore to have testimony that the drift action for a thousand miles, east and west along the Laurentian crest, and an unknown distance north of it was too violent to admit of

drift deposits, even the boulders being swept off. South of the crest the waters were less violent, and deposits commenced. In northern Wisconsin, the impinging of the current against the line of precipice flanking Green Bay valley left the marks of violent disturbance in the great gravel range. In northern Illinois the gravel shades off into clay, and in Central Illinois the ancient Pliocene soil is not stripped from the surface, nor even the stumps, nor the rotten logs that lay upon it removed. This could not be had the country been scraped by the advance of a glacier, but might readily occur were it submerged by turbid waters coming to rest after their southward rush.

Another remarkable fact, is the sudden retirement of the drift waters after the deposit of the orange loam above mentioned. No sea or large lake remains long at or near the same level, without throwing up a beach or eroding a bluff which when produced is as indestructible as any other geological monument. Ancient beach lines have little tendency to disappear. The basins of the great lakes like so many cups were left full of water, and the ancient beaches are perfectly distinct to-day up to their very brims, but outside, on the seaward slope there are no such lines. From the uplands of Wisconsin to the Ohio river there is a descent of over 1300 feet on which the most diligent search has failed to find a single beach. The Illinois Central Railroad, which runs two north and south lines the whole length of Illinois, has spent much money in vain, to find such ridges to furnish gravel for their tracks. The chief engineer, Mr. Clark, informs me that there is positively no beach line crossing either of their routes. It follows that the waters at length retired with a degree of suddenness that left no time to accumulate beaches. It is possible that this sudden retirement, and the consequent rush of waters was the cause of the valleys of our streams being excavated to such an enormous breadth as compared with the feeble brooks that now meander through them.

I see it stated in a recent Smithsonian volume that the fossils of western drift are fresh water, and of the eastern deposits marine. So far as this region is concerned I think this must be a mistake, for after fifteen years search I have never been able to find nor hear of a well authenticated fossil of any kind in the true boulder drift, except such as seemed to belong to the previous formations—Pliocene, or older; and even these are surprisingly rare, when we reflect that the drift action passed over a region already teeming with animal and vegetable life. It cannot be, however, that they are totally absent on any theory we adopt. If the glacier theory be true, terminal moraines are haunted by all sorts of land animals, and where the materials are

fertile they are soon covered with vegetation which is often buried *in situ* by temporary advances in the glacier. Besides, insects die on the ice, and falling leaves are blown into its crevasses. If the theory of submergence be preferred, then aquatic fossils should be found, and one would hardly suppose that any violence of the currents would wholly destroy them. If we adhere to the theory of submergence we must of course refer the erosion and smoothing of the rocks to the violent action of floating ice. Without venturing any dogmatic opinion on these difficult points, it seems to me that the phenomena favor the following inferences.

1. The western boulder drift is a stratified water deposit.
2. A breadth of some 200 miles along its southern border rests on the Pliocene soil, small patches of which are also found a hundred miles north of Chicago.
3. The drift does not merge directly into the loess but is separated from it by a bed of soil.
4. The waters of the drift had at the north a great velocity, and a depth of over 800 feet above Lake Michigan, but as it passed southward the water lost its swiftness and deposited its sediment.
5. A considerable depth of stiller water remained after the cessation of the great current, long enough to deposit the thin stratum of orange loam.
6. The final retirement of the drift waters from this region was rather sudden, the water falling at least 1300 feet without leaving any beach lines.

81 Monroe st., Chicago, June 7, 1869.

ART. XIX.—*Contributions from the Sheffield Laboratory of Yale College.* No. XX.—*On Durangite, a fluo-arsenate from Durango in Mexico;* by GEORGE J. BRUSH.

THE stream-tin deposit of Durango in Mexico is well known among American mineralogists for the remarkable specimens of tin-stone, as well as for the beautiful crystals of topaz which it affords. Quite recently a bright orange-colored mineral has been found at that locality, and I am indebted to Mr. Henry G. Hanks, of San Francisco, for the opportunity of investigating it. Mr. Hanks generously placed at my disposal three small crystals, with the request that I would examine the mineral and describe the species should it prove to be new.

The crystals have a rhombic aspect; color, bright orange-red, almost exactly the shade of the Uralian chromate of lead;

streak, cream yellow; lustre, vitreous. Cleavage distinct in two directions, corresponding to two of the planes of the crystals at an angle of 110° 10′, according to measurements by Mr. J. M. Blake, who makes the crystallization monoclinic. (See note on the crystallization of the mineral, at the close of this article.) Hardness =5; specific gravity =3·95–4·03.

When treated in the closed tube the mineral blackens at a moderate temperature, but regains its color on cooling; at a higher heat it fuses easily to a yellow glass and gives a faint white sublimate; this sublimate proved to be volatile, and the glass appeared dimmed from corrosive action. Not the least trace of moisture was perceptible in the closed tube. In the open tube the same reactions were observed, with the addition that blue litmus paper was reddened when inserted in the upper end of the tube. On charcoal fuses readily, and in R. F. gives a strong arsenical odor and coats the coal with a faint white volatile sublimate. With soda the arsenical odor is more marked, but in R. F. the assay affords no reducible metal. When fused with dry carbonate of soda and charcoal powder in a matrass yields a metallic ring of arsenic; with borax and salt of phosphorus it gives only a reaction for iron, while with soda it yields a manganese-green. In the forceps, fuses with intumescence at 2 and gives a strong soda flame.

The mineral is only partially attacked by chlorhydric and nitric acids, but is completely decomposed by sulphuric acid, with evolution of fluohydric acid. A qualitative examination showed the presence of arsenic acid, alumina, iron, manganese, soda, lithia and fluorine. Search was made for other metallic acids, as well as for the rarer earths and metals, with a negative result; it also proved to be free from phosphoric acid and chlorine.

The very small quantity of mineral which I felt at liberty to use for the quantitative determinations has prevented my making the examination as complete as I could desire; but I have been able to obtain direct duplicate estimations of every constituent except fluorine. This last element must exist in considerable quantity in the substance, as the fluohydric acid evolved on attacking the mineral by sulphuric acid in a platinum vessel etched glass with great readiness and distinctness. The following results were obtained:

	I.	Oxygen.	II.	III.
Arsenic acid,	55·10	19·16	53·22	----
Alumina,	20·68	9·63	20·09	----
Ferric oxyd,	4·78	1·44	5·06	----
Manganous oxyd,	1·30	0·30	1·28	----
Soda,	11·66	3·01	----	11·86
Lithia,	0·81	0·43	----	0·70
Fluorine,	undetermined.			

In No. 1, the decomposition was effected by sulphuric acid, the arsenic acid was reduced to arsenous acid by sulphurous acid, and the arsenic precipitated by sulphydric acid gas as ter-sulphid; this last was re-dissolved in fuming nitric acid, and after freeing the solution from most of the acid by evaporation it was made ammoniacal and the arsenic acid precipitated by the ordinary magnesia mixture, and estimated as ammonia-arsenate of magnesia. The iron and alumina were thrown down by ammonia and subsequently separated by caustic soda; the small amount of manganese remaining with the iron was separated from it by converting the iron into basic acetate and oxydizing the manganese by means of bromine. A portion of the manganese also was found with the alkalies; these were weighed first as sulphates; the manganese was then separated by soda and the lithia determined as phosphate. The precipitates were examined as carefully as possible, considering their small amount, and found to be pure.

In No. 2, the decomposition was made by fusion with carbonate of soda. This was dissolved in water, acidulated with chlorhydric acid and reduced as before. The low amount of arsenic acid may be due to the fact that the soda fusion was made over a gas blast-lamp, and possibly a portion of arsenic acid was reduced to arsenous acid and volatilized; or the loss may be attributed to other accidental causes.

No. 3 was a qualitative-quantitative analysis in which only the alkalies were estimated; the soda and lithia were first weighed as sulphates, then converted into chlorids, and the alkalies separated by dissolving the chlorid of lithium in a mixture of absolute alcohol and ether. The alkalies examined with the spectroscope showed only the lines of sodium and lithium.

The oxygen ratio in No. 1, between the protoxyds, sesqui-oxyds and arsenic acid is 3·74 : 11·07 : 19·16, or, very nearly, 1 : 3 : 5. This involves the assumption that the small amount of manganese exists as protoxyd, of which we have no proof, but it seems probable that this ratio is the true one, although it is impossible at present to determine the exact state of oxydation of the iron and manganese. This composition and ratio suggest an analogy between the new mineral and amblygonite, a fluo-phosphate of alumina, lithia and soda, and it may be viewed as an arsenic-acid amblygonite, containing a small percentage of iron and manganese and more soda than lithia.

The formula may be written $(\frac{1}{4}\dot{R}^{2} + \frac{1}{4}\ddot{R})\ddot{A}s$, and, as in amblygonite, a portion of the oxygen is replaced by fluorine. A number of hypotheses showing the possible relation of the fluorine might be suggested, but until further investigation these

are unnecessary. I hope before long to be able to obtain a sufficient quantity of the mineral to continue the study of its composition. The results here given are sufficient to demonstrate it to be a new species, and I believe it to be the only observed native *fluo-arsenate.* I propose for it the name *Durangite.*

Preliminary Note on the Crystallization of Durangite; by JOHN M. BLAKE.

I defer, for the present, a detailed account of my observations on this mineral, with the hope that I may have an opportunity to examine other specimens better adapted for measurement, and the study of the habit of the species. The angular measurements, as well as the optical characters distinguish the species, and show that the crystals are monoclinic, and that they do not correspond either with amblygonite or the other anhydrous phosphates and arsenates, of which I have been able to find crystallographic descriptions, and belonging in the division to which the chemical characters appear to assign this mineral.

An approximation in all the angles, to those of keilhauite, and sphene, is interesting. The figure of keilhauite* is so good a representation of the crystals of Durangite, that for present purposes it may be used for illustration, by making *I* the cleavage plane, and omitting *O* and the plane there marked $-2i$, which were not found, and adding $4i$, which occurs in sphene, and on Durangite is a small plane of infrequent occurrence.

ART. XX.—*Remarks on the Galvanic Battery;* by G. W. HOUGH, Director Dudley Observatory.†

THE constant use of Daniell's battery for nearly ten years, made us desirous of more fully understanding the mode of its action, and the cause of the decline in the strength of the electric current. For this purpose, during the past year, a series of experiments were instituted, with batteries of various forms. As they were undertaken solely for the purpose of securing the best form of battery for every day use, delicate instruments were not provided, and consequently great precision of measurement could not be obtained.

The Galvanometer consisted of a steel needle one and a half inches in length, attached to a light strip of brass, having a radius of five inches. This needle was mounted horizontally over a coil of silk-covered copper wire. The graduation of

* See Dana's Mineralogy, 5th edition, p. 387.

† Abstract read at the Chicago meeting of the American Association.

the instrument was effected by two methods, viz: by means of the divided current, and by the revolving disk.

The Rheostat was constructed by winding No. 30 silk-covered wire, around a wooden cylinder ten inches in circumference and 8 inches in length. The coils were separated in different groups, and so connected with switches that any number could readily be introduced in the circuit.

For measuring the comparative resistance of different liquids, two small platinum plates, attached to protected wires, were fastened to a block of wood, and maintained at a uniform distance from each other.

Daniell's Battery.—The battery originally constructed by Daniell consisted of a copper cylinder 6 inches high and $3\frac{1}{2}$ inches in diameter, with a porous cell or ox-gullet passing through the center, in which was suspended a rod of zinc 6 inches in length, and $\frac{1}{2}$ inch in diameter. The porous cell passed through the bottom of the copper cylinder and the end was connected with a glass siphon, bent in such a manner that the top was on a level with the surface of the liquid. The battery was excited with a saturated solution of sulphate of copper and water acidulated with sulphuric acid. When fresh water and acid was poured in the top of the porous cell, an equal amount of liquid was forced out from the bottom through the siphon. It was intended by this arrangement to maintain at all times the same strength of acidulated water about the zinc. After this battery came in general use, porous clay cells were substituted for the membranous bag, and the siphon was discarded.

Hill's Battery.—As many of our experiments were made with Hill's modification of Daniell's battery, a description of its peculiarity is deemed necessary. This battery consists of a glass jar, with a sheet of copper placed in the bottom and a disk of zinc, perforated in the center, suspended horizontally near the top. Protected copper wires are attached to the zinc and copper forming the two poles of the battery. When thus arranged the jar is filled with a solution of *s. z.** after which a few crystals of *s. c.* are dropped in through the orifice in the zinc, and lie on the copper plate. If the liquid is not agitated the copper will lie in a solution of *s. c.* and the zinc in a solution of *s. z.*, so long as the specific gravity of the latter is less than 36° B. The intervening liquid *s. z.* acts as a protection in the same manner as the porous cell in Daniell's battery.

The formation of Sulphate of Zinc.—As soon as the poles of the battery are joined *s. z.* is formed in the cell containing

* The following abbreviations are used: *q.* Quantity of electricity flowing in the external circuit; *s. c.* sulphate of copper; *s. z.* sulphate of zinc.

the zinc, and metallic copper is deposited on the copper plate. A long series of experiments were instituted to determine the rate of formation of the *s. z.*, during the various conditions of the battery. A Hill's element was put on a closed circuit through the galvanometer, without any external resistance, and the specific gravity of the *s. z.* was measured daily, by means of a Baumé hydrometer. The indications of the galvanometer needle and the temperature, was also ascertained at the same time. The jar containing the liquid was 7 inches high and 6 inches in diameter. The zinc and copper plates each presented a surface of 28 square inches. The distance between the plates was $5\frac{1}{2}$ inches. The battery was started with *s. z.* at 21° B. specific gravity. This element was on a closed circuit for 30 days; at the end of that time the *s. z.* was nearly saturated 43° B., temperature 50°, and *q.* had decreased to only one seventh of its normal value. For the first 23 days, or while the specific gravity of the *s. z.* was less than 40° B., *q.* was sensibly the same from day to day.

It is a fundamental principle that the formation of *s. z.* is directly proportional to the quantity of electricity passing in the circuit. This would be strictly true, provided there was no local action; but actual experience demonstrates that this condition is never fulfilled. On laying down the daily results in the form of a curve, having the specific gravity of the *s. z.* for one ordinate, and the time for the other, it was found that the observations could be well represented by an equation of the second degree in which $\Delta_1 = +1{\cdot}66°$ and $\Delta_2 = -0{\cdot}08°$. For this element, the amount of liquid saturated with *s. z.* between the limits 12° to 40° B., was 3·6 cubic inches daily. A second element of the same size in which the distance between the plates was reduced to 4 inches, gave similar results. But the amount of liquid saturated daily was nearly twice as great, with but a small increase in the quantity of electricity generated; showing a much greater local action.

The experiments with a Daniell's element of the usual size, using a porous cell $2\frac{1}{2}$ inches in diameter and 7 inches high, gave 5·7 cubic inches for the amount of liquid saturated daily, during the normal condition of the element. As *q.* was nearly double that of Hill's element, and the amount of liquid saturated, less in proportion, it shows less local action. From these experiments it follows that once having determined *q.* the length of time the battery will maintain the currents at its normal force can readily be computed; since it depends entirely on the capacity of the cell holding the sulphate of zinc. With a porous cell of the usual size, when no external resistance is introduced, the battery will begin to decrease at the

end of three days and at the end of five days there will be scarcely any action. On the contrary with Hill's element, of the size before described, *q.* will continue uniform for more than thirty days, and will be but little less at the end of fifty days.

Most of the writers on galvanism seem to imagine that sulphuric acid is essential for exciting the battery, but our experiments show that this is not the case; in fact we consider it a detriment; for if too great a quantity is used, crystals of sulphate of zinc are deposited on the zinc, thereby greatly lessening *q.* It seems to me that the only office of the sulphuric acid, is to make the water a better conductor; since nitric acid, muriatic acid, salt, sulphate of copper, or sulphate of zinc, will answer equally well. By using a solution of *s. z.* of a certain specific gravity, the same quantity and electro-motive force is obtained, as with sulphuric acid. This is also true for Grove's and the bi-chromate of potash battery.

The use of a number of porous cells in the same jar.—Since the decrease of *q.* is due to the formation of *s. z.*, the question naturally arises, how can a battery be constructed that will give a uniform current for a long period of time? The answer is plain, we must increase the capacity of the cell in which the zinc is placed.

In a two-gallon stone jar, three porous cells were placed with a sheet of copper surrounding them. The current was then passed through the galvanometer and rheostat, and sufficient resistance inserted to make *q.* equal to that due to a single cell, when used alone. The amount of *s. z.* formed in a given time was then measured, when it was found each cell made as much *s. z.* as if only a single one had been employed. This combination showed very great local action. Nothing, therefore, would be gained by such an arrangement, but on the contrary a much greater amount of zinc would be consumed without advantage.

We next had constructed large porous cells 6 inches in diameter and 7 inches high having a capacity of 180 cubic inches. Our previous experiments enable us to calculate with considerable precision the length of time one of these elements will maintain a maximum current of electricity. Allowing 5·7 cubic inches for the amount of liquid saturated daily between the limits 12° to 40°, it is apparent that a battery of this size should remain constant for more than 30 days, without any external resistance being introduced in the circuit. When electro-magnets are operated, as the external resistance should at least be equal to that of the battery, the current would remain constant for more than two months on a continually closed circuit.

The relation between the quantity of electricity and the specific gravity of the sulphate of zinc.—Svanberg's experiments are quoted by recent writers to prove that the electro-motive force for Daniell's battery is not materially changed by the nature of the liquid about the zinc. Although this statement is strictly true, yet it does not give us correct views in regard to the battery. We prepared different solutions of *s. z.* ranging from zero to saturation. These were alternately used in the porous cell and *q.* measured by the galvanometer. The time for each experiment was about five minutes. Above the specific gravity of 15° B. *q.* was sensibly the same up to saturation. These results were so directly contrary to all our experience with the battery in actual use, that at first we were at a loss to understand them. The experiments were accordingly continued, by putting an element on a closed circuit through the galvanometer. The quantity of electricity and the specific gravity of the *s. z.* was then noted from time to time. So soon as the *s. z.* approached near saturation, from 43° to 46° B. depending on the temperature, it was found that the element gradually decreased in force until finally *q.* was less than one twentieth of its normal value. As the electro-motive force remained constant it indicated an internal resistance more than twenty times as great. But we know by direct experiment that a saturated solution of *s. z.* is a better conductor than a dilute solution, and hence we ought to expect the resistance to be less. A careful study of the phenomena led us to conclude that the increased resistance was due to the polarization in the battery itself. When the current is passed through a voltameter or electrolyte solution, it is found a much greater resistance is introduced, than that due to the liquid alone. This increased resistance is ascribed to polarization of the electrodes in the solution and has been ably discussed by a number of scientists. But the polarization in the battery itself does not appear to have been investigated. After an element has been on a closed circuit for a long time, if the circuit be opened for a few minutes, on closing it, the galvanometer will at first indicate the maximum quantity due to the element, but in a few seconds the needle will gradually recede and stand as before. It appears that when the specific gravity of the *s. z.* approaches saturation it becomes charged with electricity like a Leyden jar or prime conductor. From numerous experiments, we find *q.* reaches its maximum when the specific gravity of the *s. z.* is between 20° and 30° B. However, for practical purposes the battery gives essentially the same force between 15° and 38° B. Below 15° B. the conducting power of the *s. z.* is considerably less, and consequently the resistance greater, and above 38° B.

the resistance is again increased by polarization. The conducting power of *s. z.* was found to be essentially the same between 30° B. and saturation. At 1° B. it was one fourth, at 7° one half, and at 14° three fourths as great as for a saturated solution.

On the use of the negative metal in Daniell's Battery.—The negative metal in Daniell's battery is only useful as a conductor of the current.

For the purpose of testing the correctness of this conclusion, experiments were made with the following metals as the negative plate: 1, Copper; 2, sheet lead; 3, sheet iron; 4, sheet iron tinned (the ordinary sheet tin); 5, sheet zinc; 6, cast zinc.

The *s. c.* was a saturated solution, and the *s. z.* had a specific gravity of 25° B. The quantity of electricity and the electromotive force was found to be the same for copper, lead, iron and tin. When zinc was used for both the positive and negative metal, the action was somewhat different. For two or three seconds after immersion in the *s. c.* there was a small negative current, after which the galvanometer needle was gradually deflected until it indicated a quantity of electricity nearly equal to the normal condition of the element. It then remained at rest for a few seconds after which it receded and stood at a degree indicating about one half the quantity. The whole time required to bring it to rest, was three minutes from the time of immersion. During the progress of the experiment the hydrogen was evolved so rapidly from the zinc immersed in the *s. c.* that the bubbles could be exploded by holding a lighted match near the surface of the liquid. As soon, however, as the galvanometer came to rest, the evolution of hydrogen had nearly ceased. On removing the zinc it was found covered with a loose copper powder, not reguline metal but such as is deposited when a large battery is employed to act on a small surface. This powder did not adhere closely to the zinc, but was separated by a thin layer of *s. z.* or hydrogen. On washing the zinc and repeating the experiment, precisely similar results were obtained. Although the zinc was capable of conducting the maximum quantity of electricity, yet the electro-motive force was considerably less than for the other metals. A careful examination of these experiments, leads us to the conclusion that the negative metal in Daniell's battery, only acts as a conductor of the electricity.

On the internal resistance of the battery.—In a battery with two liquids the internal resistance is made up of two elements, viz: the specific resistance of the liquid, and the resistance of the porous cell. Although recent writers have remarked the variation of resistance due to different kinds of earthen cells, yet

we have not learned that any one has determined separately the resistance due to the cell and that due to the liquids. By our method it is necessary to use at least two cells of different size. In these experiments three were employed—

No. 1, White clay cell 0·31 inches in thickness, 6 inches in diameter and 7 inches high.
No. 2, White clay cell 0·15 inches in thickness, 3 inches in diameter and 7 inches high.
No. 3, Split-leather cell 0·06 inches in thickness, 5 inches in diameter and 7 inches high, fitted to a bottom of inch pine.

The resistance of the element was first determined for each cell separately. Then the cells were placed one inside of the other and the total resistance determined as before. After which it was found for two at a time. These several determinations gave us a series of equations, involving the resistance of each separate cell together with the specific resistance of the liquids.

The following are the results expressed in an arbitrary unit.

No. 1,	resistance,	22
No. 2,	"	17
No. 3,	"	7

Specific resistance of the liquids *s. c.* saturated solution, *s. z.* 25° B. 13. From which it appears that the specific resistance of the liquids is about the same as for a white clay cell of the ordinary size.

As *q.* is increased by lessening the internal resistance, other things being equal, it is apparent that the leather cells are superior to those made of white clay.

On the construction of Daniell's battery.—For a local battery, where the external resistance is small, two-gallon stone jars may be used for the vessel holding the *s. c.* solution. The negative plate is best made of sheet lead instead of copper as heretofore; as it it is less expensive and is easier bent in the proper form. It is desirable to perforate the sheet with an ordinary punch, in order to secure a more free circulation of the liquid surrounding it. Ordinary sheet tin makes the cheapest negative plate, but it is unfit for general use, where the battery is required to be kept in constant action for a long period. For if the *s. c.* solution is not kept saturated, chemical action takes place between the iron and tin which soon dissolves the plates. I have, however, used it successfully. If the solution is kept saturated, in a month or so the sheet will be covered with a fine plate of copper, which may be easily separated, provided the original plate has been properly prepared by being oiled and black-beaded before being used. The porous cell in

which the zinc is placed should have a capacity of at least 150 cubic inches. As the resistance of large clay cells is more than three times as great as for those made of leather, the latter are preferred; since with the same surface of zinc, *q.* is nearly doubled. The constant use of leather cells during the past year fully demonstrates their superiority over those made of white clay. For it is found in practice that for working magnets such as are used in telegraph offices for local sounders, one element as described above gives more effective working force than two of those in ordinary use. The zinc casting may be of any form; for cells of this size, it should have an external surface of 50 square inches.

The battery should be started with *s. z.* at 15·° B. specific gravity. Sulphuric acid should never be used in the cell containing the zinc. Crystals of *s. c.* are suspended in a bag or perforated cup near the top of the liquid surrounding the negative plate, in order to keep the solution at saturation. After a battery has been in constant use for a number of months, crystals of *s. c.* will be found precipitated on the bottom of the jar. When this is the case, the liquid must be poured in another vessel, and all the *s. c.* removed, as it seems to lessen *q.* During cold weather the battery may be improved by adding occasionally a little sulphuric acid to the *s. c.* solution. Between 40° and 100° Fahr., the specific resistance of the liquids is increased about one sixth for every 10° decrease of temperature. It is not desirable therefore, to work the battery at a temperature below 50° Fahr.

The zinc need not be amalgamated, but it should be cleaned once in two or three months, and all the sediment removed from the porous cell.

When the specific gravity of the *s. z.* approaches 40° B. one half of the liquid should be removed, and fresh water added. It is always best, however, to keep the specific gravity of the *s. z.* between the limits 15° to 38° B.

If Hill's form of battery is employed, a jar of the same size may be used. With plates of 50 square inches each, placed at a distance of 5 inches from each other, *q.* is the same as for a Daniell's element of the ordinary size. The negative plate may be made of sheet lead, having a protected copper wire firmly attached to it. The zinc should be cast with an opening in the center of one and one half inches in diameter. Iron bars for supporting it near the top of the jar, can be cast in the zinc. This battery should be started with a solution of *s. z.* having a specific gravity 15·° B. The *s. c.* is dropped in through the orifice in the zinc plate. The battery should be examined occasionally with the hydrometer, and the specific gravity of the liquid never allowed to become greater than 36·° B.

ART. XXI.—*Contributions of the Massachusetts Institute of Technology.* I.—*On Nitric Acid and Chlorate of Potassium as an Oxydizing Mixture applicable to Sulphur, Sulphids, Chromium, Arsenic, Organic Matters, etc.;* by FRANK H. STORER, Professor of General and Industrial Chemistry in the Massachusetts Institute of Technology.

SOME years since while studying the action of various oxydizing agents upon oxyd of chromium, I was struck by the superior oxydizing power of a mixture of ordinary nitric acid and chlorate of potassium over that of the mixtures of chlorate of potassium and chlorhydric or sulphuric acid, commonly used in analysis. Inasmuch as the fact of the great oxydizing power of a mixture of nitric acid and the chlorate had already been noticed and explained by several observers,* I at that time contented myself with a simple statement of my own observations of the action of the mixture upon chromic oxyd† without referring in any way to the general value of the mixture as an oxydizing agent. Since that time, however, I have had frequent occasion to employ the mixture for effecting the oxydation of many substances, besides oxyd of chromium, such as present themselves in the ordinary experience of an analytical laboratory, and have satisfied myself that the merit of the process has not hitherto been duly appreciated.

Experience has convinced me, not only that a mixture of nitric acid and chlorate of potassium oxydizes more rapidly than the common mixture of chlorhydric acid and chlorate of potassium, but that it is really to be preferred in the great majority of cases to any of the agents ordinarily employed to effect oxydation in the wet way. Instead of occupying as now a secondary or alternative place in the treatises on analysis it ought to take precedence of the other processes of oxydation. It may be used with advantage in many instances where dry methods of oxydation are now recommended. With the exception perhaps of the sulphids, or other compounds, of antimony and tin, there are probably but few cases where its use will be found inadmissible.

The following notes include the results of several researches made by students of the Massachusetts Institute of Technology with the view of testing the capabilities of the process :—

* Compare Gmelin's Handbook of Chemistry, iii, 61.

† Proceedings of American Academy, 1859, iv, 342; Journal für practische Chemie, lxxx, 44.

Estimation of Sulphur in Organic Compounds; by A. H. Pearson.

It is easy to determine sulphur in non-volatile organic compounds by oxydizing the substance with chlorate of potassium and nitric acid, precipitating the sulphuric acid as sulphate of barium and washing the latter with a solution of acetate of ammonium, to remove any nitrate of barium which may have adhered to it.

To oxydize the sulphur compound, place a weighed quantity of it in a porcelain dish, pour upon it three or four table spoonfulls of strong nitric acid (39° B.), free from sulphuric acid, and add to the acid half a teaspoonful of chlorate of potassium. Cover the mixture with an inverted glass funnel, the stem of which has been bent to a right angle. Place the dish on a wire gauze support and heat its contents. From time to time lift the funnel slightly and throw a small fragment of chlorate of potassium into the hot acid.

The funnel must be of such size that its rim may fall within the rim of the dish and rest securely upon the sides of the dish, above the liquid; it serves to retain the particles of liquid which are thrown up from the dish by the gas evolved during the decomposition of the chlorate.

The oxydation will be completed more or less rapidly according to the character of the substance operated upon. Only five or ten minutes are required to completely oxydize a third of a gram of sulphocyanid of potassium, while from half to three quarters of an hour are needed to destroy the same weight of ordinary free sulphur. It may be observed in passing, that sulphur which has just been distilled dissolves twice as rapidly in a mixture of nitric acid and chlorate of potassium as sulphur which has long been exposed to the air.

Several samples of sulphocyanid of potassium, oxydized in this way, gave the following results:—

A. 0·2015 grm. of the sulphocyanid gave 0·5114 grm. of sulphate of barium. (I).

A. 0·265 grm. of the sulphocyanid gave 0·6547 grm. of sulphate of barium. (II).

B. 0·149 grm. of the sulphocyanid gave 0·3796 grm. of sulphate of barium, (I).

B. 0·012 grm. of the sulphocyanid gave 0·03 grm. of sulphate of barium. (II).

C. 0·101 grm. of the sulphocyanid gave 0·2387 grm. of sulphate of barium.

D. 0·028 grm. of the sulphocyanid gave 0·067 grm. of sulphate of barium. (I).

D. 0·084 grm. of sulphocyanid gave 0·204 grm. of sulphate of barium. (II).

The sulphocyanid used for the experiments mentioned in the paragraphs marked "A" was prepared by fusing together ferrocyanid of potassium, carbonate of potassium, and sulphur in the usual way, treating the fused mass with hot alcohol and allowing the alcoholic solution to crystallize. That used for the experiments in paragraphs B was prepared in precisely the same way as the foregoing, but at another time. The salt prepared in this way is evidently contaminated with free sulphur, or some sulphur compound other than the sulphocyanid, which has been taken up by the alcohol.

The experiment recorded in paragraph C was made with crystals which separated from the alcoholic mother-liquid of B.

The experiments marked D, were made with purified crystals obtained as follows:—A quantity of the crude alcoholic crystals, similar to those used in experiments B, were dissolved in water, the solution was filtered to separate sulphur and placed under a bell glass, over strong sulphuric acid, to crystallize. The crystals thus obtained were redissolved in alcohol, the solution filtered to separate carbonate of potassium, then concentrated by evaporation and made to crystallize. The crystals were quickly pressed between folds of filter paper and portions of them were weighed out for the analyses.

The crystals obtained directly from the aqueous solution of the sulphocyanid were contaminated to a considerable extent, with carbonate of potassium, but after they had been recrystalized from alcohol only traces of the carbonate were found upon them.

Stated in terms of per cents, the results may be tabulated as follows:—

		Found. I.	Found. II.	Theory.
A.	Impure crystals.	34·85	33·91	
B.	Impure crystals.	34·98	34·33	
C.	----------	32·45	-- --	32·90
D.	----------	32·85	32·86	32·90

I have applied the foregoing method not only to sulphocyanid of potassium and to free sulphur as above described, but also for estimating sulphur in vulcanized caoutchouc and in several samples of anthracite and bituminous coal. It is easy to completely oxydize either of these substances by means of the mixed chlorate of potassium and nitric acid. Anthracite dissolves even more readily than bituminous coal, since, unlike the latter, it does not fuse to a single mass in the hot acid.

It is not improbable that by a slight variation of the foregoing process it may be found practicable to determine the carbon of an organic compound at the same time as the sul-

phur. Thus, the oxydation might perhaps be effected in a flask provided with a wide funnel tube for the addition of the chlorate and a delivery tube through which the carbonic acid formed could be led into baryta-water or some other substance fit to absorb that gas. Upon this point, however, I have as yet made no experiments.

May, 1869.

Assay of Sulphur in Iron Pyrites ; by A. H. PEARSON.

The proportion of sulphur in iron pyrites ("Sulphur-ore") may be readily and accurately estimated as follows :—Weigh out a gram or less of the powdered ore, place the powder in a porcelain dish, together with a small quantity of chlorate of potassium, pour upon it some 50 c. c. of pure nitric acid of 39° B., and cover the mixture with an inverted glass funnel, with bent stem. Set the dish upon a water bath and heat the water to boiling. From time to time throw crystals of chlorate of potassium into the hot acid. By adding rather large crystals of the chlorate at frequent intervals it is easy to oxydize the whole of the sulphid in half an hour. But since the solution obtained in that case is highly charged with saline matter it will usually be found more advantageous to use less of the chlorate of potassium and to allow a somewhat longer time for the process of oxydation.

When all the sulphur has been oxydized, rinse the funnel with water and remove it from the dish. Evaporate the liquid to a small bulk, then add to it a little concentrated chlorhydric acid and again evaporate to absolute dryness in order to render silicic acid insoluble. Moisten the residue with concentrated chlorhydric acid, mix it with water and filter, to separate silicic acid and gangue.

To the filtrate from the silicic acid add a quantity of solid tartaric acid about as large as that of the pyrites originally taken, heat the liquid almost to boiling and add to it an excess of chlorid of barium to precipitate the sulphuric acid. After the sulphate of barium has been allowed to subside, wash it thoroughly by decantation first with hot water and afterward with a dilute solution of acetate of ammonium. The latter may be prepared at the moment of use, by mixing ammonia-water and acetic acid. The purpose of the acetate of ammonium is to dissolve any nitrate of barium which may adhere to the sulphate ; that of the tartaric acid is to prevent the precipitation of iron compounds together with the sulphate of barium. In an experiment where 0·7 grm. of pyrites was oxydized with chlorate of potassium and nitric acid, and the

filtrate from silica was acidulated with chlorhydric acid without the addition of tartaric acid, there was thrown down on the addition of chlorid of barium a bright yellow precipitate which became darker colored when the solution was boiled. It was not only found to be impossible to wash out the iron with which this precipitate was contaminated but the consistency of the precipitate was such that it was a difficult matter even to wash away the saline liquor in which the precipitate was formed.

In another experiment, the attempt was made to remove the iron from the filtrate from silica before adding the barium salt to throw down the sulphuric acid. But in that case a considerable portion of the sulphuric acid was dragged down, as sulphate of potassium, by the iron precipitate and so lost. The precipitation of the iron was effected in this experiment by adding an excess of ammonia-water to the acidulated filtrate from silica and washing the precipitate for a long time, by decantation, with boiling water. To prove that the iron precipitate really retained sulphuric acid a quantity of the precipitate was dried, ignited and powdered and the powder boiled with water. The clear liquid thus obtained was acidulated with chlorhydric acid and tested with chlorid of barium. An abundant precipitate of sulphate of barium was at once thrown down.

After the sulphur of the pyrites has been determined by precipitating it from a tartaric acid solution, as above described, the iron might perhaps be estimated in the filtrate by one of the new methods of titration with hyposulphite of sodium. I have made no experiments with the hyposulphite, but have failed completely in several attempts to determine the iron as a sulphid, by precipitating with sulphid of sodium, as directed by Fresenius. I found it impossible to wash the sticky, slimy mass of sulphid of iron. It is not easy, on the other hand, to destroy the tartaric acid by igniting the dried filtrate, from sulphate of barium, in a muffle, for on evaporating this solution the saline matters with which it is charged continually creep over the edges of the dish.

November, 1868.

Assay of Copper pyrites; by F. P. Pearson.

The following method of treating copper pyrites has been found more advantageous than the ordinary process of oxydizing the mineral with aqua regia and subsequently evaporating the solution repeatedly with chlorhydric acid, or with sulphuric acid, to expel the last traces of nitric acid :—

Place a weighed quantity of the powdered mineral together with some chlorate of potassium in a porcelain dish.—Five grams of a variety of pyrites containing about 18 per cent of copper was found to be enough for one analysis, and a quantity of chlorate of potassium equal to a small teaspoonful, was added to the ore.—Invert a glass funnel with bent stem in the dish above the pyrites and pour upon the latter rather more ordinary strong nitric acid than would be sufficient to completely cover the powder. Place the dish upon a water-bath, and, from time to time, throw into it small quantities of chlorate of potassium. The doses of the chlorate must be repeated at frequent intervals until free sulphur can no longer be seen in the dish. If need be, add nitric acid also from time to time, to replace that lost by evaporation.

As a general rule it is safer and more convenient to heat the mixture on a water-bath than upon sand, though I find that the oxydation of sulphur can be effected more easily and quickly when the mixture of nitric acid and chlorate is heated to actual boiling than at the temperature obtainable by means of a water-bath. When the last particles of sulphur have been destroyed remove the inverted funnel from the dish, rinse it with water and collect the rinsings in a beaker by themselves. Allow the liquid in the evaporating dish to become cold, pour upon it a quantity of ordinary strong chlorhydric acid rather larger than the quantity of nitric acid taken at first, evaporate the mixed solution to dryness and heat the dry residue, to render silica insoluble in case any silica be present.

Pour water upon the cold residue, and, without filtering the liquor, wash the contents of the dish into the beaker which contains the rinsings of the funnel. Heat the liquid in the beaker nearly to boiling, add to it about 25 c. c. of a strong aqueous solution of ferrous sulphate slightly acidulated with sulphuric acid, and keep the mixture at a temperature near boiling during four or five minutes, in order to destroy the small quantity of nitric acid which has escaped decomposition in spite of the evaporation with chlorhydric acid.

The ferrous salt seldom or never acts instantaneously, but the reducing action proceeds rapidly and perfectly satisfactorily when once begun. If need be, add more of the ferrous solution, little by little, until the entire contents of the beaker became dark colored, or almost black, and no more gas is disengaged.

In order to be sure that all the nitric acid has been reduced, it is well enough, after the mixture of liquid and solution of ferrous sulphate has been duly heated, to place a drop of the mixture upon porcelain and test it with ferricyanid of potas-

sium. In general, however, the coloration of the liquor in the beaker due to the formation of nitrous or hyponitric acid will be a sufficient indication that the copperas has done its work. The nitrous fumes quickly disappear from the liquid at a subsequent stage of operations when metallic iron is immersed in the solution.

When enough of the ferrous sulphate has been added, filter the mixed solution into a wide beaker, precipitate the copper, in the metallic state, upon a sheet of iron in the usual way and ignite the copper in a porcelain crucible, in a current of hydrogen, before weighing it.

By means of the ferrous salt, the last traces of nitric acid may be got rid of far more quickly, conveniently and certainly than by the old system of evaporating the pyrites solution with several successive portions of chlorhydric acid. By treating the pyrites with chlorate of potassium and nitric acid it is easy to oxydize and dissolve every particle of the sulphur in the mineral so that no portion of the latter can escape decomposition by becoming enveloped in free sulphur. When aqua regia is used on the other hand, or a mixture of chlorate of potassium and chlorhydric acid, a certain proportion of sulphur almost invariably remains undissolved and might easily enclose portions of the mineral so as to protect them from the solvent action of the acids.

The method of oxydation above described can manifestly be employed with advantage for dissolving many other sulphuretted ores besides copper pyrites.

January, 1869.

Estimation of Sulphur in Sulphid of Mercury; by E. W. Bowditch.

In order to contrast the action of the mixed nitric acid and chlorate of potassium with that of the mixture of chlorhydric acid and chlorate of potassium ordinarily employed by chemists, as an oxydizing agent, a series of comparative experiments were made upon commercial vermilion.

Eight portions of the vermilion were operated upon in succession, as follows :—In each instance about 0·5 or 0·6 grm. of the vermilion was placed in a small glass flask set in an inclined position upon a wire gauze support above a lamp. A quantity of nitric acid, of 39° B., or of concentrated chlorhydric acid as the case might be, was poured into the flask, a small quantity of chlorate of potassium was added and the mixture heated. From time to time small bits of chlorate of potassium were thrown into the flask, the contents of which were maintained near the boiling point until all the sulphur, or as much of it as possible, had dissolved.

In every instance where nitric acid was employed, the vermilion was in a short time oxydized and dissolved so completely that no trace of free sulphur could be seen in the liquor. But when chlorhydric acid was used to decompose the chlorate, there remained, invariably, floating upon the liquid, one or more yellow globules of undissolved sulphur, varying in size from that of a pin's head to a flax seed. These floating globules could not be destroyed by any practicable amounts of the chlorate and acid. In fact, it may be said to be impossible to destroy such globules with these reagents.

Whenever chlorhydric acid was used, therefore, to decompose the vermilion, the solution obtained had to be filtered, to separate the free sulphur, before the sulphuric acid in the solution could be precipitated as sulphate of barium. The presence of free sulphur is objectionable not only because time is lost in collecting, washing, drying and weighing it, but also on account of its liability to enclose and conceal particles of the substance to be analyzed, which would be dissolved by the acid if the latter were able to act upon them. The determination of sulphur may thus be rendered incorrect by weighing the undissolved substances with the sulphur.

When nitric acid was used with the chlorate, it happened sometimes, when the proportion of nitric acid was small, that a considerable quantity of saline matter crystallized in the flask. It was found, however, that enough water to redissolve this precipitate might be added to the mixture without impairing to any material extent the oxydizing power of the chlorate subsequently added. The acid liquor resulting from the action of nitric acid and chlorate of potassium upon the vermilion was evaporated to dryness on a water bath and the residue treated with strong chlorhydric acid in order to destroy most of the nitric acid before proceeding to precipitate the sulphuric acid with chlorid of barium. Before adding the chlorhydric acid to the residue the latter must be allowed to become perfectly cold lest the mixture froth violently and portions of it be thrown out of the flask. After the acid has once been added, however, the mixture may be heated gently without risk of loss.

No matter whether chlorhydric or nitric acid is employed with the chlorate, the solution must at last be largely diluted with water before adding the chlorid of barium.

In my experiments, nothing but hot water was employed to wash the sulphate of barium. Naturally enough it was more difficult to wash in this way the precipitates obtained from solutions contaminated with nitric acid, than those from the solutions which contained only chlorhydric acid. But in spite

of this disadvantage and of the long time required to wash out the last traces of nitrate of barium I have always found that a sulphur determination made by the nitric acid process requires much less time for its completion than one made by the old way with chlorhydric acid.

In a final trial made expressly for the purpose of testing this point, the precise times consumed in making each experiment were carefully noted. Two portions of the vermilion were weighed out into flasks and treated, one with chlorhydric acid and chlorate of potassium and the other with nitric acid and the chlorate. The portion treated with chlorhydric acid weighed 0·5695 grm. and the other 0·519 grm. The flask containing the sample treated with chlorhydric acid was taken from the fire a few minutes before the last traces of sulphur in the nitric acid flask had been destroyed and the separation of the undissolved sulphur was proceeded with as rapidly as possible, but in the end it was found that eleven hours and three quarters were required to complete the determination of sulphur in the portion of vermilion treated with chlorhydric acid while the estimation of sulphur in the other portion, treated with nitric acid was finished in nine hours and a half. 14·32 per cent of sulphur was found in the portion treated with nitric acid and 14·25 per cent in the portion treated with chlorhydric acid, instead of the 13·79 per cent required by theory.

February, 1868.

Estimation of Chromium as Chromate of Barium; by A. H. Pearson.

As Prof. Storer has shown,* chromic oxyd is quickly changed to chromic acid, when boiled with a mixture of concentrated nitric acid and chlorate of potassium. All the chromium in half a gram of hydrate of chromium or of any of the ordinary chrome salts can in this way be converted into chromic acid in a few moments, and even compounds as refractory as chrome-iron-ore, or oxyd of chromium which has been strongly ignited, can be oxydized in less time than would be required to complete their oxydation by the process of fusion ordinarily employed.

As will appear from the experiments which follow, the chromic acid thus formed in the wet way, can be readily and accurately estimated in the form of chromate of barium, if care be taken to wash the precipitated chromate with acetate of ammonium or some other saline solution in which chromate of barium is insoluble.

I. A quantity of anhydrous chromic oxyd was prepared by heating bichromate of potassium with an excess of strong chlor-

* Proceedings of American Academy, 1859, iv, 342.

hydric acid, until chlorine ceased to be evolved, saturating the acid liquor with ammonia water, washing and drying the precipitated hydrate and finally igniting it intensely in a platinum crucible over a blast-lamp.

0·102 grm. of this anhydrous oxyd was placed in an evaporating dish, together with a quantity of nitric acid and some chlorate of potassium, and covered with an inverted funnel with a bent stem. The acid was heated and fragments of chlorate of potassium were added to it from time to time, until the chromic oxyd had completely disappeared. This result was attained in the course of half an hour.

The acid solution was diluted with water, then neutralized with ammonia and the ammoniacal solution in its turn treated with enough acetic acid to make it slightly acid. After the acidulated solution has become cold, a solution of chlorid of barium was added to it, in slight excess, and the mixture was left at rest for ten or twelve hours. The precipitated chromate of barium was washed, by decantation, with a cold solution of acetate of ammonium, then collected on a filter, rinsed with water, dried, heated in a crucible to expel the last traces of water and of the ammonium salt, and weighed.

The amount of chromate of barium obtained in this experiment was equal to 0·336 grm., which is equivalent to 68·31 per cent of chromium instead of 68·62 per cent as required by theory.

The precipitate of chromate of barium must be allowed to stand for some time before filtering lest it pass through the pores of the filter and render the filtrate cloudy.

The acetate of ammonium employed for washing serves to dissolve any nitrate of barium or chlorid of barium which may have been precipitated with the chromate. It has the further advantage of dissolving less of the chromate of barium than pure water would.

II. A quantity of hydrate of chromium precipitated from a solution of reduced bichromate of potassium, as in the previous experiment, was dried at 115° and the proportion of water retained by the dried hydrate was determined once for all by ignition.

0·11 grm. of this dried hydrate, equal to 0·0688 of the anhydrous oxyd, was then treated with nitric acid and chlorate of potassium as in experiment I. It was found that the oxydation was completed as soon as the acid became hot enough to decompose the chlorate. Less than five minutes were sufficient in this instance for the complete conversion of the chromium to chromic acid.

The chromate of barium obtained weighed 0·2286 grm., equiv-

alent to 68·65 per cent of chromium in the oxyd taken instead of the theoretical 68·62 per cent.

III. 0·113 grm. of the dried hydrate containing 0·0707 grm. of the anhydrous oxyd of chromium was mixed with a quantity of nitrate of magnesium,—prepared by dissolving carbonate of magnesium in nitric acid—before the treatment with nitric acid and chlorate of potassium. 0·2346 grm. of chromate of barium was obtained. In other words, 68·60 per cent of chromium instead of the 68·62 per cent required by theory.

IV. 0·114 grm. of the dried hydrate of chromium, containing 0·0713 grm. of the anhydrous oxyd, was mixed with nitrate of aluminum,—prepared by dissolving hydrate of aluminum in nitric acid—before the treatment with chlorate of potassium. 0·2356 grm. of chromate of barium, was obtained. That is to say, 68·31 per cent of chromium instead of 68·62 per cent.

V. A small quantity of chrome-iron-ore was ground to very fine powder and treated in a dish with nitric acid and chlorate of potassium as above described. At the end of half an hour, that portion of the ore which still remained undissolved was washed with water, dried, fused with a mixture of carbonate of sodium and nitrate of potassium, and the fused mass boiled with water; but the solution thus obtained gave no reaction for chromium when tested for that substance.

It appears from the foregoing experiments that chromium can be readily estimated, in this way, in presence of aluminum and magnesium. The process can doubtless be employed also for separating chromium from iron, cobalt, nickel and zinc. As a matter of course, special care must always be taken to employ reagents which are absolutely free from any contamination of sulphuric acid.

April, 1869.

On the use of Chromate of Barium in Quantitative Analysis; by R. H. Richards.

A sample of pure bichromate of potassium examined simultaneously by three of the students in the Institute's laboratory for the purpose of determining the percentage of chromium by precipitating that element in the form of chromate of barium, gave the following discordant results. The method of analysis was similiar to that described below.

Name of experimenter.	Grms. of $K_2O, 2CrO_3$ taken.	Grms. of BaO, CrO_3 found.	Percentage of Chromium. Found.	Theory.
N. F. Merrill,	0·516	0·8640	34·67	35·56
F. P. Pearson,	0·500	0·8788	36·38	" "
C. E. Avery,	----	----	36·31	" "
" " "	----	----	36·24	" "

At the suggestion of Prof. Storer, I have examined other portions of the same sample of bichromate of potassium, with the view of discovering, if possible, the sources of error which vitiated the foregoing analyses.

A quantity of the bichromate was heated until it fused, the cold mass powdered and several portions of it, weighing from one to two grams each, were taken for analysis. Each of the weighed quantities of bichromate was dissolved in distilled water, the solution was heated nearly to boiling and a lump of acetate of sodium twice the volume of the bichromate of potassium taken was thrown into the hot liquor. Acetic acid was then added to strongly acid reaction, and afterward a solution of chlorid of barium, with occasional stirring, until no more precipitate was formed on the further addition of chlorid of barium and until the supernatant fluid became absolutely colorless. It is easy to hit this point in a hot solution but not so easy when the liquid is cold.

After the precipitate had been allowed to stand for some time, the clear liquid above it was decanted into a filter. The precipitate was then washed with cold water, first by decantation in the beaker and afterward upon the filter. The filtrate proper, that is to say, the clear liquor decanted from the precipitate, was in every instance colorless. It gave a white residue when evaporated on platinum foil and no precipitate when tested with acetate of lead. But all the subsequent liquors obtained by decantation and washing came through the filter distinctly yellow-colored. They gave yellow residues when evaporated upon foil and bright yellow precipitates when tested with acetate of lead. It was, consequently, no easy matter to determine when to stop washing. The precipitates were in fact put aside to dry as soon as there was any reason to suppose that the saline mother-liquor had all been washed out from them.

In the 2nd or the following experiments the chromate of barium was weighed upon a tared filter, as was the case also in the experiments cited above, but in Nos. 1, 3 and 4 the dry precipitate was ignited gently in a porcelain crucible before weighing.

No. of the Experiment.	Grms. of $K_2O, 2CrO_3$ taken.	Grms. of BaO, CrO_3 found.	Percentage of Chromium found.	Theory.
1.	1·0095	1·7301	35·47	35·56
2.	1·0175	1·8444	37·53	
3.	1·5456	2·7541	37·74	
4.	1·5020	2·5696	35·49	

Experiments 3 and 4 were carried out side by side, and every effort made to treat them exactly alike.

From the appearance and behavior of the wash-water, as above described, it appears that chromate of barium is somewhat soluble in pure water, but is insoluble in tolerably strong saline solutions, even in the presence of acetic acid. This observation agrees in the main with a statement* in Prof. Storer's Dictionary of Solubilities to the effect that "chromate of baryta is very slightly soluble in water, and even insoluble when other salts are present in solution."

On the other hand, the excess of precipitate found in experiments 2 and 3, would go to show that chlorid of barium is liable to be dragged down by chromate of barium in the same way that it is apt to go down with sulphate of barium. It would appear therefore that some saline solution, competent to dissolve chlorid and nitrate of barium, should be used instead of water for washing chromate of barium. [P. S.—In accordance with this view Mr. A. H. Pearson has recently employed a solution of acetate of ammonium, with the best results, for washing both the chromate and the sulphate of barium.]

April, 1868.

Approximate Determinations of the Solubilities of Nitrate of Barium, Chlorid of Barium, Perchlorate of Potassium and Chlorate of Potassium in several saline solutions; by A. H. PEARSON.

The following experiments were undertaken in order to discover a saline solution proper to wash out from precipitated chromate of barium the difficultly soluble substances which might be thrown down with it in the operations described above, on page 199.

Quantities of dry nitrate of barium, chlorid of barium, perchlorate of potassium (tolerably, but not absolutely, pure), and chlorate of potassium were finely powdered and a number of small equal portions of each of the powders were measured out into test-tubes. The contents of each of the tubes were then treated with successive drops of the solvent until the last particles of the powders had dissolved. A special dropping tube was provided for each of the solvents and the drops were of such size that 50 of them were very nearly equal to 1 c. c. The test-tubes were thoroughly shaken immediately after the addition of each drop of the solvent, then allowed to stand for some time and again shaken before adding another drop of the liquid. Due allowance was made for the excess of liquid in case the last drop of the solvent was manifestly more than sufficent to dissolve the last traces of the salt.

The powdered salts were measured in a small glass tube, such as is provided in Plattner's blowpipe apparatus, for measuring

* Cited from Dumas's Traité de Chimie appliquée aux Arts.

powdered lead. As the mean of several weighings, it was found that the charge of nitrate of barium weighed 0·15 grm., that of chlorid of barium 0·12 grm., that of perchlorate of potassium 0·1 grm. and that of chlorate of potassium 0·08 grm.

For the experiments made "at the temperature of boiling water," long, narrow open tubes, to condense aqueous vapor, were fitted to the mouths of the test-tubes by means of perforated corks and the test-tubes were kept immersed in a bath of boiling water. By means of pasteboard screens the tops of the tubes were protected from the steam and heat of the bath.

The results of the experiments may be tabulated as follows:—

Nitrate of Barium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·15 grm.) BaO, N_2O_5.	No. of c. c. of the solvent required to dissolve one grm. of BaO, N_2O_5.
Water,	100	13·33
Chlorid of ammonium,	104	13·67
Ammonia water (strong),	110	14·67
Acetate of sodium,	110	14·67
Ammonia water (weak),	124	16·50
Acetate of ammonium,	130	17·33
Acetate of copper,	130	17·33
Grape-sugar,	140	18·67
Nitrate of ammonium,	180	24·00
Chlorhydric acid (dil.),	210	28·00
Acetic acid,	220	29·00
Nitric acid (dil.),	Insoluble.	

II. Experiments made at the temperature of boiling water.

Acetate of ammonium,	33	4·33
Water,	35	4·67
Chlorid of ammonium,	35	4·67
Acetate of sodium,	40	5·33
Ammonia water (strong),	43	5·67
Acetate of copper,	45	6·00

Chlorid of Barium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·12 grm.) of $BaCl_2$.	No. of c. c. of the solvent required to dissolve one grm. of $BaCl_2$.
Water,	24	4·00
Ammonia water (strong),	30	5·00
" " (weak),	32	5·33
Chlorhydric acid (dil.),	32	5·33
Grape sugar,	34	5·67
Acetate of ammonium,	36	6·00
Chlorid of ammonium,	36	6·00
Acetate of copper,	38	6·33
Acetate of sodium,	40	6·67
Acetic acid,	48	8·00

Perchlorate of Potassium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·1 grm.) of K_2O, Cl_2O_7.	No. of c. c. of the solvent required to dissolve one grm. K_2O, Cl_2O_7.
Nitrate of ammonium,	80	16
Water,	110	22
Nitric acid (dil.),	112	22·4
Acetate of ammonium,	122	24·4
Chlorid of ammonium,	128	25·6
Acetate of sodium,	128	25·6
Cane sugar,	136	27·2
Acetate of copper,	146	29·2
Ammonia water (conc.),	148	29·6
" " (dil.),	152	30·4
Chlorhydric acid (dil.),	152	30·4
Grape sugar,	184	36·8
Acetic acid,	226	45·2.

II. Experiments made at the temperature of boiling water.

Water,	20	4·00
Nitrate of ammonium,	20	4·00
Nitric acid (dil.),	25	5.00
Acetate of ammonium,	30	6·00
Chlorid of ammonium,	30	6·00
Acetate of copper,	35	7·00
Acetate of sodium,	35	7·00

Chlorate of Potassium.

I. Experiments made at the ordinary temperature of the air.

Name of solvent.	No. of drops of the solvent required to dissolve the charge (= 0·08 grm.) $KClO_3$.	No. of c. c. of the solvent required to dissolve one grm. of $KClO_3$.
Nitrate of ammonium,	72	18·00
Water,	118	29·50
Nitric acid (dil.),	122	30·50
Chlorid of ammonium,	126	31·50
Acetate of copper,	126	31·50
Acetate of sodium,	130	32·50
Chlorhydric acid (dil.),	132	33·00
Cane sugar,	134	33·50
Acetate of ammonium,	136	34·00
Ammonia water (strong),	142	35·50
Grape sugar,	146	36·50
Ammonia water (weak),	156	39·00
Acetic acid,	192	48·00

The strengths of the various solutions employed as solvents were as follows :—

Ammonia-water, strong = ordinary liquor ammoniæ.
Ammonia-water, weak = a mixture of 1 volume of the strong ammonia-water with 3 vols. of water.
Nitric acid, dilute = a mixture of 1 volume of the strong acid (of 39° B.), with 5 vols. water.
Chlorhydric acid, dilute = 1 vol. of the ordinary concentrated acid with 4 vols. water.
Acetic acid = 1 vol. of the commercial acid mixed with 1 vol. of water.
Chlorid of ammonium = 1 part of the crystallized salt in 10 parts of water.
Nitrate of ammonium = 1 part of the crystallized salt in 10 parts of water.
Acetate of ammonium = ammonia-water dilute, neutralized with the acetic acid of the given strength.
Acetate of sodium was made by saturating a quantity of commercial acetic acid with carbonate of sodium and diluting the liquid with 4 volumes of water.
Acetate of copper was prepared according to the directions of Stolba.*
Cane sugar = 1 part of sugar in 10 parts of water.
Glucose (starch sugar)=1 part of sugar in 10 parts of water.

It will be observed that the solvent power of acetate of copper,—recommended by Stolba for washing sulphate of barium,—is inferior to that of several other salts.

It may here be said that contrary to what might be supposed, no perchlorate of potassium seems to be carried down with chromate or sulphate of barium when these salts are precipitated, in the estimation of chromium or of sulphur, as described on pp. 191 and 198. At all events none of the perchlorate could be detected on searching for it in several samples of sulphate of barium precipitated from liquors obtained by oxydizing sulphur and sulphur compounds with a mixture of nitric acid and chlorate of potassium.

The method employed in testing for the perchlorate was as follows :—A few drops of an aqueous solution of iodid of potassium were placed in a porcelain crucible together with a small quantity of thin starch paste ; the mixture was acidulated with chlorhydric acid, free from chlorine, and a quantity of the precipitate to be tested was stirred into the mixture. In no instance did the starch become blue on the addition of the precipitate, although nothing but water was used for washing the latter. But a blue coloration was immediately produced, whenever a

* Zeitschrift analyt. Chem., ii. 390.

small speck of perchlorate of potassium was added to the acidulated mixture of starch and iodid.

January, 1869.

Arsenic Compounds.—Of the experiments with arsenic compounds, it will be sufficient to say that both metallic arsenic and arsenious acid are easily changed to arsenic acid by the action of nitric acid and chlorate of potassium, and that the arsenic acid thus formed may be precipitated without inconvenience in the form of arseniate of magnesium and ammonium.

Boston, May 20, 1869.

ART. XXII.—*On the Action of Light on Uranium;* by H. CARRINGTON BOLTON, Ph.D.

COMPOUNDS of uranium were found to be sensitive to the sun's rays at a very early period in the history of the element. Klaproth, who discovered uranium in 1789, makes no allusion to the property in question, but Bucholz in 1805 remarked the effect of light on solutions of the sulphate and nitrate. Since Bucholz's discovery seems to have escaped the observation of most chemists, I may be allowed to quote from his communication published in the "Annales de Chimie et de Physique," for 1805.

"Sulphate of uranium dissolves in 25 parts of alcohol, and the solution undergoes remarkable changes on exposure to the sun, the yellow liquid becomes turbid, and deposits a grayish green substance. After several days' exposure, the solution acquires an odor resembling nitric ether, rather than sulphuric; the filtrate is colorless and contains no uranium; the precipitate is of a green color, and retains sulphuric acid."

Bucholz remarks in another paragraph: "Nitrate of uranium is very soluble in ether, and the yellow solution exposed to the sun's rays becomes green, an odor of nitric ether is developed, and a black substance is precipitated." Chemists added little to these facts for many years; Gehlen observed that the oxychlorid was sensitive to the light, when in a solution containing alcohol; Berzelius states, in his "Lehrbuch," that the precipitate formed in the solution of the sulphate is a basic protosalt, and adds that the precipitate produced by the reduction of the nitrate has not been examined.

In 1841, Ebelmen* made a complete investigation of the decomposition of the oxalate of the sesquioxyd. He writes in

* Ann. Ch. Pharm., xliii, 286.

the "Annalen der Chemie und Pharmacie": "On exposing a solution of the oxalate of the sesquioxyd of uranium to the action of the sun's rays, the liquid becomes turbid and deposits a brown violet mass. Carbonic oxyd and carbonic acid, in varying proportions, are evolved throughout the experiment. The liquid becomes colorless and the precipitate begins to turn yellow, and when dried on a filter changes into a yellow mass, the hydrate of the sesquioxyd. The ease with which the violet precipitate absorbs oxygen, makes its examination difficult. When washed and dried *in vacuo*, it forms a hard black mass, of conchoidal fracture, resembling some varieties of pitchblend." After describing certain experiments with this violet precipitate, Ebelmen pronounces it to be a hydrate of the green oxyd.

Ebelmen also examined the action of light on the sulphate of uranium. He dissolved the three-fourths oxyd in concentrated sulphuric acid, diluted with water and alcohol, and exposed the solution in a stoppered bottle. Little by little crystals attached themselves to the sides of the vessel, while the liquid acquired the odor and characteristic reactions of aldehyde. The green crystals proved to be sulphate of the protoxyd of uranium. Ebelmen confirmed Bucholz's observation with regard to the alcoholic solution of the sulphate of the sesquioxyd, and established the composition of the green precipitate formed in the sunlight. He calls it bibasic sulphate of the protoxyd, having the formula $2UO, SO_3+2HO$.

A year later, Lucien Bonaparte* found that the valeriana e of the sesquioxyd was decomposed on exposure to the sunlight in a similar manner to the oxalate. He calls the violet precipitate obtained, valerianate of the protoxyd; is it not rather Ebelmen's hydrated green oxyd?

Péligot, Rammelsberg, Wertheim, and other chemists, who subsequently made extensive researches on uranium, do not appear to have examined its actinic reactions. Neither Herschel nor Hunt, in their valuable researches on light, notice the discoveries made up to this date. I can find no mention of investigations on this subject, until the year 1857, when C. J. Burnett† published his discovery of the use of uranium salts in photographic printing.

It seems strange that attempts to employ uranium were not made at an earlier date, when it is remembered that Bucholz's discovery, in 1805, was contemporaneous with those of Sir H. Davy and Wedgewood, who procured the first sun-pictures of which we have authentic record. Burnett was quickly followed by Niepce de St. Victor,‡ who rediscovered processes similar to

* J. prakt. Chem., xxx, 308.
† Liverpool Journ. Phot., 1857.
‡ Compt. Rend., xlvi, 449.

Burnett's, and obtained a patent for them in February, 1858. We have no evidence that Niepce de St. Victor was ignorant of Burnett's invention. Credit, however, is due to him for an experimental illustration of the remarkable property possessed by nitrate of uranium of absorbing actinic rays of light, and retaining them in an active condition for a long time. He exposed behind a negative, paper strongly impregnated with nitrate of uranium, and then hermetically sealed it in metallic tubes. This paper retains the power of darkening chlorid of silver, for weeks and even months. On opening a tube, and placing the paper on a sensitive surface, an image is obtained identical with that of the negative employed.

In the following year, Niepce de St. Victor, together with Corvisart,* discovered that the presence of a small quantity of nitrate of uranium increased ten-fold the action of light on amylaceous matter, converting it into dextrine and glucose. They also remarked the decomposition of oxalic acid in presence of nitrate of uranium, with formation of carbonic acid. Corvisart's last-mentioned experiment was repeated by Seekamp† with greater accuracy; he employed solutions containing 5 per cent oxalic acid, and 1 per cent oxalate of uranium; 100 c. c. of this solution, exposed to light for three minutes, furnished 22 c. c. of gas, which consisted of carbonic oxyd and carbonic acid. Seekamp observed the formation of crystals of oxalate of the protoxyd, and determined the presence of formic acid in the solution. The same chemist subsequently examined the action of light on the succinate and pyrotartrate of uranium.‡ The succinate acid is converted into propionic acid, and the pyrotartaric into butyric. A detailed account of these interesting reactions would lead us into the field of organic chemistry.

The processes for printing with salts of uranium were modified by numerous photographers among whom Hagen in Germany, Draper and Cary Lea in this country made the chief improvements. In 1860 Wothly§ announced that he had discovered a process for printing entirely dispensing with salts of silver and requiring no fixing except washing. This statement attracted much attention and photographers awaited details: but two or three years afterward when the process became known by the publication of the specification, its value was found to be exaggerated. Both nitrate of silver and hyposulphite of soda were employed and the only novelty consisted in

* Compt. Rend., xlix, 368; also Bull. Soc. Chim., 1862, 62.
† Ann. Chem. Pharm., cxxii, 113. ‡ Ann. Chem. Pharm., cxxxiii, 253.
§ Bull. Belge de Phot., 1864. Original announcement in Horn's Photog. Journ. for 1860.

the use of collodion and of a method of combining a salt of uranium with one of silver.

Having thus sketched the history of the action of light on uranium, I will return to Burnett's and Wothly's photographic processes. According to Burnett, ordinary paper is sensitized by floating on a bath of nitrate of uranium and hung up to dry. By exposing this paper behind a negative from one to thirty minutes (according as direct rays or diffused light are employed) a weak image is obtained which is then developed by a bath of nitrate of silver or of chlorid of gold. Simple washing being insufficient to remove the excess of silver salt, a bath of hyposulphite of soda may be used with advantage.

By developing with ferricyanid of potassium, red pictures are obtained, and by floating these red ones on a bath of sesquichlorid of iron, green pictures result.* Burnett, who studied this whole subject with care, did not confine himself to the use of nitrate of uranium, but experimented with the oxalate, tartrate, formiate, citrate, acetate, succinate, benzoate, chlorate, bromate, oxychlorid, oxybromid, and oxyfluorid. He tried both acid and ammoniacal solutions. Not having been able to obtain Burnett's original communications to the "Liverpool Journal of Photography," I cannot give details of results obtained with the various salts, but the nitrate being a commercial article, is the only one which ever came into use. Burnett's efforts to obtain pictures on glass plates in a camera were unsuccessful.

Wothly prepares a double salt by crystallizing together nitrate of uranium and silver, and sensitizes a resinized collodion with this substance. Paper prepared in a special manner with arrowroot starch and albumen is then coated with the sensitized collodion. After exposing the print, which requires no development, it is toned with chlorid of gold, washed with dilute acid and fixed with sulphocyanid of potassium or hyposulphite of soda. The pictures obtained by this process are said to be very beautiful and of a characteristic tone.

In 1866 when studying the compounds of uranium in the laboratory of the University of Göttingen, I obtained a salt having the formula $2(U_2O_2Fl)+3KFl$. It is prepared by adding a slight excess of fluorid of potassium to a solution of nitrate of uranium, washing the slightly soluble precipitate and crystallizing it from a hot solution. It forms yellow fluorescent crystals belonging to the monoclinic system.† When a solution of this salt acidified with formic acid, is exposed to direct sunlight, decomposition ensues, a green precipitate falls,

* The writer invariably obtained *blue* pictures; compare photograph No. 15.

† Berl. Akad., Ber. 1866, 299.

and the liquid becomes colorless; the precipitate is insoluble in water and dilute acids, and has the composition 4(U Fl)+ K Fl. Oxalic acid effects a similar reduction, but with the formation of Ebelmen's violet hydrate as secondary product. I have made many attempts to obtain green prints with this salt. Last winter I exposed behind a negative, paper sensitized with oxyfluorid of uranium and potassium to which a little formic acid was added. After ten days constant exposure faint indications of a picture were perceptible.* This was not very promising, but I recently repeated the experiment, first floating the paper on a bath of formic acid and then on a bath of oxyfluorid of uranium and sodium, it being more soluble than the corresponding potassa salt. In one hour a weak print is obtained which scarcely becomes darker by longer exposure; owing to the simultaneous formation of the green fluorid and the violet hydrate, the picture when first printed presents a singular appearance. Simple washing with water removes the excess of uranium salt and fixes the green parts, but the violet parts turn yellow and weaken the image.† Could the formation of the violet hydrate be prevented, one might obtain uniform prints of a delicate green. By exposing paper sensitized as above for a shorter period, one to two minutes, and developing with nitrate of silver or ferricyanid of potassium the usual black and red pictures may be obtained. These, however, are no novelty, but experiments with certain metallic salts to ascertain their value as developers brought out some interesting results.‡

At this time, not fully cognizant of the completeness of Burnett's experiments, I attempted printing with other salts of uranium. The formiate I found too insoluble though it furnished pictures, the same objection applies to the oxalate. According to my experience, after the nitrate, the ammonio-citrate of uranium is the most sensitive salt. This double salt was prepared by neutralizing a given weight of citric acid with oxyd of uranium and an equal portion of the acid with ammonia, mixing the solutions and evaporating. The golden yellow solution showing no tendency to crystallize, it was evaporated to dryness and gave a semi-vitreous mass somewhat resembling citrate of iron. The uranium in a solution of this salt is not precipitated by many reagents; an excess of ammonia is without effect, ferricyanid of potassium and sulphid of ammonium only darken the liquid, the presence of citric acid preventing their action as in the case of iron, manganese and aluminium. On boiling with caustic potash the solution is decomposed with

* See Photograph No. 1.

† See Photographs No. 2 and No. 3.

‡ See Photographs Nos. 20 to 24.

precipitation of uranate of potash. The salt is insoluble in alcohol which throws it down from an aqueous solution. This ammonia-citrate is the only compound of uranium which I have observed to be sensitive to sunlight in the dry state. The yellow powder turns dark brown on exposure to the direct rays of the sun. The change is far more striking with the solution, which rapidly acquires a deep brown red color without depositing a precipitate. This red solution turns yellow on standing a few days in an open glass, but preserves its color much longer in stoppered bottles. Owing to the presence of citric acid (which prevents precipitation after exposure as before) it is very difficult to determine what compound of uranium exists in this solution. On evaporating to dryness on a water bath a brown powder is obtained resembling that formed by exposing the dry salt. Potash produces in the *red* solution a *green* precipitate which gradually turns *yellow*. This reaction leads me to believe that the red solution contains the suboxyd U_3O_2 discovered in 1863 by a French chemist named Guyard. By the prolonged action of zinc on the sesquioxyd dissolved in hydrochloric acid, Guyard obtained a deep red solution which furnished a green precipitate with alkalies.*

Nitrate of uranium is not only very soluble in water, alcohol and ether, but also in glycerine. Even when deprived of its water of crystallization the nitrate dissolves in pure glycerine.

The syrupy liquid exhibits the same behavior with reagents as an aqueous solution. On exposure to the sunlight the yellow solution turns green and finally becomes reddish brown without depositing a precipitate; no evolution of gas was perceptible. The brown liquid yields a dark brown precipitate with ammonia and this precipitate washed and dissolved in acids forms green solutions. It is probably a mixture of protoxyd and suboxyds. An aqueous solution of the nitrate with a few drops of glycerine, acquires on exposure a green hue and contains only the protoxyd. The transformation of the glycerine is reserved for further investigation.

Solutions of the sulphate, oxychlorid and oxyfluorid of uranium mixed with glycerine, are reduced in a similar manner; the double oxyfluorid of uranium and sodium (or potassium) is reduced more rapidly than with formic or oxalic acids, forming the green precipitate in an acid solution and the violet hydrate in a neutral one.

I have printed a number of photographs with solutions of various salts to which a small quantity of glycerine was added; by comparing these prints with those obtained without glycerine I have come to the conclusion that the addition of glycerine

* Bull. Soc. Chim. 1864, i, 94.

both shortens the necessary time of exposure and quickens development. One minute's exposure yields a clear print when the paper is sensitized with the oxyfluorid of uranium and sodium with glycerine, whereas five to ten minutes is the time necessary in other processes. I recommend the use of glycerine to such photographers as may experiment with uranium pictures.

The actinic reactions of uranium salts much resemble those of iron; like the latter the sensitive uranium compounds all contain oxygen and the physical and chemical changes are due to complete or partial deoxydation. We also notice the necessary coöperation of organic matter, the part which the latter plays being clearly that of a reducing agent. Under influence of the actinic rays, the uranium salts part with some of their oxygen, which goes over to the oxydizable organic material. An aqueous solution of nitrate of uranium exposed to light in a glass vessel remains unchanged; but as soon as organic matter whether in the form of alcohol, ether, glycerine, cellulose or an organic acid, is brought in contact with the uranic solution a reduction is effected and the organic matter is oxydized at the expense of the uranium. Accordingly, salts of uranium with organic acids are for the most part sensitive as such. In the printing processes, cellulose effects the reduction, which is, however, assisted by the addition of alcohol (recommended by Hagen) or glycerine.

Attempts to obtain reactions with other agents than the actinic rays of the sun, gave negative results. A series of 23 uranium salts exposed to the light of magnesium wire, exhibited no fluorescence, nor was a solution of the oxyfluorid with formic acid reduced by exposure to the magnesium light. An experiment made with the intention of effecting reduction at a high temperature under pressure, was also unsuccessful. A solution of the oxyfluorid acidified with formic acid was heated in a sealed tube at 100° C., and afterward at 120° C. for many hours, but without producing the least change.

Details of manipulation, strength of solutions, &c., such as may be found in any practical work on photography, have been purposely omitted, it being my object to consider the subject strictly from a chemical point of view.

Description of Photographs.

No. 1. (Jan. 25, 1868.)—Common filtering paper sensitized with a mixture of oxyfluorid of uranium and potassium and formic acid. Exposed ten days. Fixed by washing. Barely perceptible outline.

The remaining experiments were made with unsalted non-albumenized *papier de saxe*. The prints were well washed before development. An unvarnished negative was used.

No. 2. (March 11, 1869.)—Sensitized 1st with formic acid, 2nd oxyfluorid of uranium and sodium. Exposed one hour. Fixed (?) by washing. A weak print, green when first obtained, turned yellow on exposure.

No. 3. Sensitized with oxyfluorid of uranium and sodium mixed with glycerine. Exposed one hour—a violet print, which turned lemon-yellow on exposure.

No. 4. Sensitized with 1st, oxalic acid; 2nd, oxyfluorid of uranium and potassium. Exposed 15 minutes. Developed with ferricyanid of potassium—fixed by washing. A red picture.

No. 6. Sensitized with citrate of uranium and ammonia. Exposed 10 minutes. Developed with ferricyanid of potassium. A clear red picture.

No. 7. Sensitized with 1st, oxalic acid; 2nd, oxyfluorid of uranium and sodium. Exposed ——. Developed first with perchlorid and then with nutgalls solution. A blue black *negative*.

No. 8. Sensitized with oxyfluorid of uranium and sodium mixed with formic acid. Exposed 1 minute. Developed with ferricyanid of potassium. A weak red print not very clear.

No. 9. Sensitized with oxyfluorid of uranium and sodium mixed with glycerine. Exposed one minute. Developed with ferricyanid of potassium—a clear well defined red print.

No. 12. Sensitized with nitrate of uranium mixed with glycerine. Exposed 2 minutes. Developed with ferricyanid of potassium. An inferior red print.

No. 13. Sensitized with nitrate of uranium mixed with glycerine. Exposed 2 minutes. Developed with nitrate of silver and fixed with hyposulphite of soda. A fair print.

No. 14. Sensitized with oxyfluorid of uranium and sodium mixed with glycerine. Exposed one minute. Developed with nitrate of silver and fixed with hyposulphite of soda. An excellent well defined picture.

No. 15. Sensitizer S = oxyfluorid of uranium and sodium with glycerine. Exposed one minute. Developed with ferricyanid of potassium and then with perchlorid of iron. A brown picture which turned light *blue* while drying in the air.

No. 16. Sensitizer S. Exposed 1 minute. Developed with ferricyanid of potassium and then with protosulphate of iron. A well defined *green* picture.

No. 18. Sensitizer S. Exposed 70 seconds. Developed with 1st, ferricyanid of potassium; 2nd, mixture of same with perchlorid of iron. A clear snuff-colored print.

Employed following developing solutions.

A = 1 grm. $K_3Fe_2Cy_6$ in 60 grms. water.
B = 20 drops Fe_2Cl_3* in 60 grms. water.
C = mixture of 1 part A and 2 parts B.
D = mixture of 1 part A and 1 part B.
E = mixture of 2 parts A and 1 part B.
F = 1 grm. $FeOSO_3$ in 60 grms. water.

No. 20. Sensitizer S. Developer C. Exposed one minute—a clear dark lead colored print having a shade of blue.

No. 21. Sensitizer S. Developer D. Exposed one minute—a brown print with a shade of red.

No. 22. Sensitizer S. Developer E. Exposed one minute; a reddish brown picture.

No. 23. Sensitizer S. Developer, 1st, A; 2d, C. Exposed one minute—a black color nearly resembling nitrate of silver prints. In several trials a blue color predominated.

No. 24. Sensitizer S. Developers A and FB. Exposed one minute. A clear greenish black picture.

The photographs enumerated above are but a small portion of those taken; some of the processes were repeated and only the best pictures retained. In describing them it is difficult to convey in words a correct idea of color, tone, intensity, clearness, &c. Inexperience in manipulation was often a cause of ill success.

No. 7 is a novelty; the chlorid of iron penetrates the paper where not reached by the light and the nutgalls bring out an ink negative. By comparing No. 8 and No. 9 we observe the superiority of glycerine. No 14 is a far better print than No. 13, which is taken by known methods. By modifying the strength of solutions A, B, C, D, E and F, and varying time of exposure and intensity of development a great variety of colors may be obtained; passing from brick red, through brown red, brown, black brown, green black, blue black to light blue, besides intermediate neutral tints. The color of nitrate of silver may be fairly imitated, but I candidly confess I have been unable to reproduce the delicacy of line, beauty of tone and finish characteristic of ordinary gold and silver prints.

New York, June, 1869.

* Ordinary commercial solution.

ART. XXIII.—*Contributions to Chemistry from the Laboratory of the Lawrence Scientific School.* No. 8.—*On the action of the alkaline nitrites upon uric acid and its derivatives;* by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

[Read before the National Academy of Sciences, April 15th, 1869.]

THE products of the action of nitrous acid upon the members of the uric acid group have been little examined. Baeyer has shown that hydurilic acid by the action of potassic nitrite yields alloxan and potassic violurate, the equation expressing the decomposition being as follows:

$$C_8H_6N_4O_6 + KNO_2 + 2HNO_2 = C_4H_2KN_2O_4 + C_4H_2N_2O_4 + 2NO + H_2O$$

The nitrous acid in this case exerts an oxydizing action and is reduced to nitric oxyd. The action of nitrous acid upon urea has long been familiar to chemists, but, so far as I have been able to find, urea and hydurilic acid are the only members of the uric acid group the relations of which to the nitrites may be considered as known. I have undertaken in some measure at least to supply this deficiency in our knowledge and present the following as the result of my work.

Uric acid was diffused in cold water and a current of the red gas resulting from the action of nitric acid upon starch or sawdust passed into the liquid; effervescence almost at once commenced and after a time the acid was wholly dissolved. On evaporation the liquid yielded an abundance of yellowish crystals together with a small quantity of a brick red insoluble substance. The crystals were easily purified by solution, treatment with animal charcoal and recrystallization. They were then perfectly colorless, but became slightly pink on drying and possessed all the properties of parabanic acid. On analysis

1·0358 gr. gave 0·1790 gr. water and 1·2103 gr. carbonic acid, corresponding to 31·86 per cent of carbon and 1·91 per cent of hydrogen.

The formula $C_3H_2N_2O_3$ requires carbon 31·58, hydrogen 1·75; the substance analyzed was therefore parabanic acid. With ammonia it yielded ammonic oxalurate, easily recognized from its characteristic properties. The red matter mixed with the parabanic acid dissolved in a very large quantity of water to an orange yellow liquid which, on cooling, deposited a reddish flocky matter in quantity too small for analysis. The mother-liquor of this substance fluoresced strongly with a blue color. In a second experiment alloxan and alloxantin were detected

in the liquid resulting from the action of nitrous acid gas upon uric acid; it is therefore shown that the gas simply exerts an oxydizing action analogous to that of dilute nitric acid. When uric acid is heated with an alkaline solution of potassic or sodic nitrite no sensible reaction occurs. The addition of any strong acid produces a violent effervescence and the uric acid soon disappears. The solution on evaporation is found to contain only salts of the alkaline metal and the usual products of the oxydation of uric by nitric acid. In this case also nitrous acid exerts no specific action.

When on the contrary acetic acid is present in small excess the alkaline nitrite acts in a wholly different manner. The uric acid dissolves with effervescence arising from the escape of carbonic acid, nitrogen and nitric oxyd, and a clear pale yellow liquid is obtained. The action is greatly facilitated by heating the mixture upon a waterbath and adding the alkaline nitrite and acetic acid alternately until the whole of the uric acid disappears, acetic acid being in small excess. On cooling, the liquid deposits crystals which vary in composition according to the conditions of temperature and concentration under which the experiment is made.

The uric acid employed in the present investigation was obtained from guano, and I am indebted for a liberal supply to the kindness of Prof. Horsford, by whom it was prepared. As the crude acid had a well marked yellow tint, various methods of purification were employed, of which the following modification of Fritzsche's process was found to be the best. The crude acid was dissolved in strong sulphuric acid with the aid of heat, and the dark brown liquid heated for some hours upon a waterbath. It was then gradually diluted with strong commercial chlorhydric acid as long as this produced a precipitate of uric acid. After the subsidence of the latter, the supernatant liquid was poured off and the uric acid washed with chlorhydric acid by decantation, and afterward with cold water. The dried mass had a faint grayish tint, and dissolved in caustic alkalies with a slight brownish color. Fritzsche states that uric acid may be obtained perfectly white by his process, but in repeated trials I have never succeeded in getting rid of the last traces of color.

Before the completion of my investigation I discovered, however, a better method of purifying the acid. Crude uric acid from guano is to be dissolved in a solution of caustic potash, any large excess of the alkali being avoided. To the solution potassic dichromate is added in quantity equal to about 5 per cent of the uric acid employed. The solution is to be boiled for a short time, diluted with an equal volume of water, agitated strongly with animal charcoal and filtered. Chlorhydric

acid then precipitates the uric acid from the solution with a pale yellowish color. After the complete subsidence of the acid the supernatant liquid is to be poured off and the uric acid boiled with strong chlorhydric acid, in repeated portions, until it becomes perfectly white and gives with caustic potash a colorless solution. In this manner a kilogram of deep yellow crude uric acid may be rendered perfectly white in little more than an hour's time.

Action of potassic nitrite.—When uric acid is heated for some time with potassic nitrite, the liquid being kept acid by the occasional addition of acetic acid, a clear yellow solution finally results, which, after filtration and cooling, usually deposits a voluminous potassic salt in fine, pale sulphur yellow needles felted together. By washing with cold water and repeated recrystallizations this salt may be obtained pure. It has then a very pale sulphur yellow color, from which it cannot be freed by treatment with animal charcoal, and a peculiar astringent bitter taste. To the acid contained in this salt I give the name of stryphnic acid, from στρυφνος, astringent-bitter. Potassic stryphnate dissolves readily in boiling water and separates almost completely on cooling—a character which it possesses in common with all the soluble salts of the same acid. Its formula when dried at 102°C., is $K(C_4H_2N_5O_2)$ as the following analyses show:

1·3513 gr. salt gave 0·1527 gr. water and 1·2410 gr. carbonic acid = 1·25 per cent hydrogen and 25·04 per cent carbon.

1·1617 gr. salt gave 0·1307 gr. water and 1·0684 gr. carbonic acid = 1·24 per cent hydrogen and 25·08 per cent carbon.

0·9345 gr. salt gave 280 c.c. nitrogen at 4° C. and 757^{mm} = 36·76 per cent.

0·7322 gr. salt gave 224 c.c. nitrogen at 6° C. and $746{\cdot}5^{mm}$ = 36·55 per cent.

0·8869 gr. salt gave 0·3978 gr. potassic sulphate = 20·12 per cent potassium.

0·6716 gr. salt gave 0·3008 gr. potassic sulphate = 20·07 per cent potassium.

The formula $C_4H_2KN_5O_2$ requires

	Calculated.	Found	
Carbon,	25·13	25·04	25·08
Hydrogen,	1·04	1·25	1·24
Nitrogen,	36·64	36·76	36·55
Potassium,	20·41	20·12	20·07
Oxygen,	16·78	----	----
	100·00		

The combustions were all made with plumbic chromate, and the nitrogen determinations with the assistance of Sprengel's mercurial pump. Crystallized potassic stryphnate contains three atoms of water to two molecules of salt:

0·6338 gr. dried in pleno over sulphuric acid lost by heating to 102° C. 0·0800 gr. water = 12·62 per cent. 100 parts of the crystallized salt,

$2(C_4H_2KN_5O_2)+3H_2O$, in becoming anhydrous should lose 12·38 per cent.

The accurate determination of the alkali in this salt is extremely difficult. The salt on being heated melts and takes an orange color. It then on carbonization intumesces and yields a mass from which the carbon cannot be burned off by the usual methods. The best results were obtained by means of Kämmerer's process,* but as seen above are only tolerably good.

In the mother-liquor from which the potassic stryphnate has separated, I have succeeded thus far in detecting only allantoin and oxalic acid, the quantity of the former being extremely variable. When the action of the alkaline nitrite has been continued for a long time, the allantoin disappears entirely. The mother-liquor in question is to be evaporated on a water bath to dryness, and the dry mass extracted with alcohol. After distilling off the alcohol basic acetate of lead yields with the aqueous solution a more or less copious white precipitate which, after washing and decomposition by sulphydric acid gas, yields a colorless solution, from which beautiful prismatic crystals of allantoin may be obtained. In one experiment, cupric acetate was added directly to the solution obtained by the action of potassic nitrite upon uric acid. A flocky blue precipitate was thrown down, and the filtrate from this deposited on standing fine colorless crystals which had all the properties of allantoin.

0·8782 gr. gave 0·3077 gr. water and 0·9779 gr. carbonic acid = 30·37 per cent carbon and 3·89 per cent hydrogen.

The formula $C_4H_6N_4O_3$ requires 30·38 per cent carbon and 3·80 per cent hydrogen.

The crystals obtained by the decomposition of the last compound obtained as above, were also analyzed:

0·8650 gr. gave 0·3121 gr. water and 0·9623 gr. carbonic acid = 30·50 per cent carbon and 4·01 per cent hydrogen.

To prove the existence of oxalic acid in the mother-liquor from the potassic stryphnate, plumbic acetate was added, the buff colored precipitate washed, treated with very dilute nitric acid and filtered. The filtrate gave abundance of beau-

* Zeitschrift für analytische Chemie, B. vi.

tiful crystals of plumbic oxalo-nitrate. Of this salt 0·7315 gr. gave 0·4933 $Pb\Theta = 67·43$ per cent; the formula $Pb(\mathrm{C}_2\Theta_4) + Pb(N\Theta_3)_2 + 2H_2\Theta$ requires 67·47 per cent. Furthermore it was found that 664 milligrams of the salt required for oxydation, 27·63 c. c. of a solution of potassic hypermanganate of which 27·73 c. c. corresponded to 16 milligrams of oxygen. This fully identifies the salt.

A portion of the lead salt precipitated by plumbic acetate from the mother-liquor of the potassic stryphnate was boiled with an excess of ammonic carbonate and the filtrate allowed to crystallize. It had all the properties of pure ammonic oxalate. 0·142 gr. required for oxydation 18·56 c. c. of potassic hypermanganate, of which 18·51 c. c. corresponded to 16 milligrams of oxygen.

These results show conclusively that oxalic was the only organic acid present. The quantity of potassic stryphnate formed by the action of potassic nitrite upon uric acid is very small, amounting to not more than five per cent of the latter; I cannot, therefore, with any reasonable degree of probability express the reaction in the form of an equation in which all the products of the decomposition shall appear. The derivation of stryphnic from uric acid may very probably be represented by the equation

$$\mathrm{C}_5H_4N_4\Theta_3 + HN\Theta_2 = \mathrm{C}_4H_3N_5\Theta_2 + \mathrm{C}\Theta_2 + H_2\Theta;$$

and the formation of allantoin by the equation

$$\mathrm{C}_5H_4N_4\Theta_3 + 2HN\Theta_2 = \mathrm{C}_4H_6N_4\Theta_3 + \mathrm{C}\Theta_2 + 2N\Theta.$$

As it seemed possible that stryphnic acid might be formed directly from allantoin by a reaction obtained by the equation

$$\mathrm{C}_4H_6N_4\Theta_3 + 2(HN\Theta_2) = \mathrm{C}_4H_3N_5\Theta_2 + HN\Theta_3 + 2H_2\Theta;$$

I endeavored, but without success, to obtain it by treating pure allantoin with potassic nitrite.

Potassic stryphnate gives with acids, after a short time, a precipitate of stryphnic acid in pale yellow granular indistinct crystals. I have not succeeded in forming an acid stryphnate and consider it therefore as most probable that the acid is monobasic. The salt gives crystalline precipitates with the salts of various metals; with cupric sulphate a pale bluish rather flocky precipitate soluble in hot acetic acid; with ferrous sulphate a flocky precipitate, which soon becomes granular crystalline and pale yellowish white; with cadmic sulphate perfectly white granular crystals; with manganous chlorid a white crystalline precipitate, and with mercurous nitrate a snow-white, very copious precipitate. The salts of barium, strontium, calcium, magnesium, lead and zinc are easily prepared by double decomposition.

Sodic stryphnate $Na(C_4H_2N_5O_2)+H_2O$, closely resembles the potassic salt, and may be obtained directly by the action of sodic nitrite upon uric acid. It is, however, more difficult to purify than the corresponding potassic salt, in consequence of the insolubility of the sodic oxalate formed at the same time. The salt crystallizes in pale sulphur yellow needles, which when large, have a bright yellow color. It is rather easily soluble in hot water and separates slowly, but almost completely, from the solution on cooling.

0·5235 gr. burnt with plumbic chromate, gave 0·4680 gr. CO_2 = 24·79 per cent carbon.
0·4352 gr. gave 0·0910 gr. H_2O = 2·32 per cent hydrogen.
0·2910 gr. gave 125·86 c. c. nitrogen at 18° C. and 559^{mm} = 36·28 per cent nitrogen.

	Calculated.	Found.
Carbon	24·86	24·79
Hydrogen	2·07	2·32
Nitrogen	36·26	36·28

In the analyses the carbon and hydrogen were determined separately as, in consequence of the large quantity of oxyds of nitrogen formed, it was found necessary to add metallic mercury to the chromate employed for combustion.

Baric stryphnate is precipitated after a short time in pale yellow needles when a solution of potassic stryphnate is added to one of baric chlorid. The salt may be washed with cold water and purified by repeated recrystallization. It dissolves readily in hot water and separates from the solution almost completely as it cools.

0·9475 gr. of the salt dried at 102° C. gave 0·1386 gr. of water and 0·7093 gr. carbonic acid = 20·41 per cent carbon and 1·62 per cent hydrogen.
0·4858 gr. gave 0·2384 gr. baric sulphate = 28·74 per cent barium.

		Calculated.	Found.
Carbon	8	20·12	20·41
Hydrogen	8	1·67	1·62
Barium	1	28·72	28·74

The formula of the salt is therefore $Ba(C_4H_2N_5O_2)_2 + 2H_2O$.

Strontic stryphnate is formed in precisely the same manner, and cannot be distinguished in appearance from the baric salt. It also crystallizes almost completely from a hot solution on cooling.

0·7526 gr. gave 0·1544 gr. SrO = 20·51 per cent. The formula $Sr(C_4H_2N_5O_2)_2 + 6H_2O$ requires 20·72 per cent SrO.

Calcic stryphnate closely resembles the baric and strontic salts. The salt analyzed was prepared by precipitating calcic

chlorid with potassic stryphnate and repeated recrystallization. Of the pale yellow needles

0·5553 gr. gave 0·5179 gr. carbonic acid and 0·1171 gr. water = 25·43 per cent carbon and 2·34 per cent hydrogen.
0·3157 gr. gave 0·0454 gr. lime = 10·27 per cent calcium.

		Calculated.	Found.
Carbon	8	25·26	25·43
Hydrogen	8	2·10	2·34
Calcium	1	10·52	10·27

The salt was dried at 102° C. Its formula is therefore

$$Ca(C_4H_2N_5O_2)_2 + 2H_2O$$

Magnesic stryphnate was prepared by precipitating magnesic sulphate with potassic stryphnate and recrystallizing. It forms very beautiful small yellow prismatic crystals. The salt was dried in pleno over sulphuric acid for analysis.

0·8429 gr. gave 0·2876 gr. water and 0·6833 gr. carbonic acid = 22·10 per cent carbon and 3·79 per cent hydrogen.
0·5080 gr. gave 0·0467 gr. magnesia = 5·51 per cent magnesium.

		Calculated.	Found.
Carbon	8	22·02	22·10
Hydrogen	16	3·69	3·79
Magnesium	1	5·50	5·51

The formula of the salt is therefore $Mg(C_4H_2N_5O_2)_2 + 6H_2O$. It is, of all the stryphnates examined, that which crystallizes most perfectly.

Plumbic stryphnate $Pb(C_4H_2N_5O_2)_2 + 3H_2O$, is precipitated from plumbic acetate as a very pale yellow granular crystalline powder which is almost perfectly insoluble in water. It becomes basic by treatment with boiling water or even by long washing with cold water.

1·3839 gr. gave 0·2332 gr. water and 0·8228 gr. carbonic acid = 16·21 per cent carbon and 1·87 per cent hydrogen.
0·6014 gr. gave 0·2298 gr. plumbic oxyd = 35·46 per cent of lead.

		Calculated.	Found.
Carbon	8	16·52	16·21
Hydrogen	10	1·72	1·87
Lead	1	35·50	35·46

A portion of the lead salt by long washing with boiling water became bright yellow, and on analysis

0·6895 gr. gave 0·0960 gr. water and 0·3219 gr. carbonic acid = 12·74 per cent carbon and 1·53 per cent hydrogen.
1·0874 gr. gave 0·6139 gr. plumbic oxyd = 52·39 per cent lead.

These results correspond tolerably well to the formula $Pb(C_4H_2N_5O_2)_2 + PbO + 3H_2O$ which requires carbon 12·48 hydrogen 1·27, and lead 52·54 per cent.

Zincic stryphnate is a pale yellowish-white granular precipitate nearly insoluble even in boiling water. Argentic stryphnate is a white gelatinous precipitate, insoluble in water and in nitric acid. This salt could not be completely washed and obtained pure for analysis.

Stryphnic acid.—When potassic stryphnate is dissolved in boiling water and an excess of chlorhydric acid is added, no precipitate is at first produced, but after standing, very pale yellowish white granular crystals are formed, and the whole of the stryphnic acid present is thrown down. The acid is soluble in boiling water and crystallizes, when the solution cools, in small indistinct crystalline grains, which have a faint but distinct yellowish tint and an astringent bitter taste. The solution has no sensible acid reaction. The acid unites directly with alkalies and expels carbonic acid from the alkaline carbonates when boiled with them.

0.6257 gr. gave 0·1734 gr. H_2O and 0·6578 gr. CO_2 = 3·08 per cent hydrogen and 28·67 per cent carbon.

0·4213 gr. gave 0·1210 gr. H_2O and 0·4428 gr. CO_2 = 3·21 per cent hydrogen and 28·66 per cent carbon.

0·3636 gr. gave 0·1078 gr. H_2O and 0·3837 gr. CO_2 = 3·29 per cent hydrogen and 28·77 per cent carbon.

0·8042 gr. gave 282 c. c. nitrogen at 15·2° C. and 758^{mm} = 40·81 per cent nitrogen.

	Calculated.	Found.		
Carbon,	28·07	28·67	28·66	28·77
Hydrogen,	2·92	3·08	3·21	3·29
Nitrogen,	40·93	40·81	----	----
Oxygen,	28·08	----	----	----
	100·00			

The large excess of carbon in these analyses is due to the extraordinary difficulty of deoxydizing by metallic copper the nitrous acid formed during the combustion.

From these analyses it appears that the formula of stryphnic acid is

$$C_4H_3N_5O_2$$

I have not found it possible to determine with certainty whether the acid is monobasic or bibasic, and have therefore adopted the simpler view. The peculiar color of the acid, as well as of its salts, leads to the suspicion that it may be a nitro-derivative and that its true formula is

$$C_4H_3(NO)N_4O.$$

Stannous chlorid and chlorhydric acid do not exert a sensible action upon stryphnic acid. When, however, the acid is digested with metallic magnesium or zinc and chlorhydric acid, the solution soon becomes yellow and finally orange. The

liquid then, on cooling, yields grouped masses of dark dull red crystals which dissolve to a deep orange red liquid becoming orange, and finally yellow, by dilution. These crystals may prove to be amido-stryphnic acid, $C_4H_3(NH_2)N_4O$. Want of material has prevented me from making a more complete examination.

In my paper on the constitution of uric acid and its derivatives,* I gave to the acid which I now term stryphnic acid the name urocyanic acid, and attributed to it the formula $C_5H_4N_6O_3$. A more extended study has enabled me to correct this formula and to select a more appropriate name. Retaining the same views as to the constitution of the members of the uric acid series respectively, that is to say, considering them as derivatives of the polymeric forms of cyanic acid, I propose for the atomic structure of stryphnic acid the formula

$$\begin{array}{l} N = C - NO \\ | \quad\quad | \\ N - C - H \\ | \quad\quad | \\ N - C - H \\ | \quad\quad | \\ N = C - HO \end{array}$$

It is therefore to be regarded as a derivative of the hypothetical tetracyanic acid, and belongs to the same group with mycomelic acid, allantoin, &c.

Action of potassic nitrite upon alloxantin.—Alloxantin treated in the cold with potassic nitrite and acetic acid dissolves completely with effervescence. The solution has a pale purplish tint and stains the skin to an onion red color. On evaporation small granular crystals of alloxan are deposited in abundance. From this it is evident that, under the circumstances, the action of the nitrous acid is one of oxydation simply. In this connection I may mention that potassic hypermanganate oxydizes alloxantin to alloxan, the end reaction being tolerably well defined. In two experiments 322 milligrams of alloxantin required 27·31 c. c. and 27·26 c. c. of a solution of the hypermanganate, of which 27·5 c. c. corresponded to 16 milligrams of oxygen. A molecule of alloxantin required therefore one atom of oxygen for oxydation.

Action of the nitrites upon alloxan.—When alloxan is boiled with a solution of sodic nitrite, acetic acid being added in small quantities, an abundant evolution of gas is observed and the filtrate on cooling deposits a white and rather insoluble salt which is sodic oxalurate. A portion of this salt was dissolved in hot water and argentic nitrate added, when a white precipitate was formed which was washed on a filter with cold water

* This Journal, vol. xlvi, p. 289, Nov. 1868.

and dissolved in boiling water. Beautiful colorless needles of argentic oxalurate were formed.

0·3925 gr. gave 0·1771 gr. silver = 45·12 per cent.
0·2821 gr. gave 0·1277 gr. silver = 45·22 per cent.

The formula $C_3H_3AgN_2O_4$ requires 45·18 per cent silver.

The formation of oxaluric acid from alloxan might be represented by the equation

$$C_4H_2N_2O_4 + H_2O + N_2O_3 = C_3H_4N_2O_4 + CO_2 + 2NO$$

It seems, however, more probable that the alloxan is first oxydized to parabanic acid which then passes into oxaluric acid by taking up an atom of water; thus

$$C_4H_2N_2O_4 + N_2O_3 = C_3H_2N_2O_3 + CO_2 + 2NO$$

and $$C_3H_2N_2O_3 + H_2O = C_3H_4N_2O_4$$

When alloxan is boiled for some time with an alkaline nitrite and acetic acid, the oxaluric acid is more or less completely decomposed into oxalic acid and urea, which last is, however, resolved, as fast as set free, into carbonic acid, nitrogen and water, according to a well known reaction.

Action of the nitrites upon alloxanic acid.—Baric alloxanate was boiled with potassic nitrite and acetic acid. The usual effervescence was observed and after some time a buff-colored crystalline barium salt was formed while the supernatant liquid had a strong yellow tint. The barium salt proved on examination to be merely not quite pure baric oxalate. It gave 59·8 per cent BaO in place of 58·4 per cent. It is, to say the least, probable, that in this case oxalic acid is a final product only, and that oxaluric acid is the intermediate product, since alloxanic acid differs from alloxan only by the elements of one atom of water.

Action upon parabanic acid.—Perfectly colorless crystals of parabanic acid were treated for a short time only with potassic nitrite and acetic acid. A strong effervescence ensued, and after cooling, large colorless crystals of a potassic salt separated, which were purified by repeated recrystallization.

0·9349 gr. gave 0·1639 gr. water and 0·7230 gr. carbonic acid = 21·09 per cent carbon and 1·94 per cent hydrogen.
0·8593 gr. gave 115 c.c. nitrogen at 6·25° C. and 762·7^{mm} = 16·50 per cent.

		Calculated.	Found.
Carbon	3	21·17	21·09
Hydrogen	3	1·76	1·94
Nitrogen	2	16·47	16·50

The formula is therefore $C_3H_3KN_2O_4$, which is that of potassic oxalurate. The salt was dried at 102° C. The acid obtained

from it possessed the characteristic properties of oxaluric acid. The corresponding sodium salt was also analyzed. 0·5729 gr. salt dried at 100° C. gave 0·1171 gr. water and 0·4910 gr. carbonic acid = 23·37 per cent carbon and 2·26 per cent hydrogen. The formula $\mathrm{C_3H_3NaN_2O_4}$ requires carbon 23·37, hydrogen 1·94 per cent.

From this result it appears that, in the presence of the alkaline salt, the parabanic acid simply unites with the elements of water to form oxaluric acid. It is not easy to say whether the decomposition which occasions the effervescence observed is due to the direct oxydation of one portion of the parabanic acid or to that of the oxaluric acid formed. In several experiments I have observed that when parabanic acid is boiled for some time with potassic nitrite but without acetic acid, a very distinct odor like that of formic acid is observed. Only oxalic acid is found among the liquid products of the reaction when the boiling is long continued, and the actual quantity of acid vapor is very small. It seems probable that a small portion of the parabanic acid is decomposed in accordance with the equation :

$$\mathrm{C_3H_2N_2O_3 + N_2O_3 = CH_2O_2 + 2CO_2 + 4N},$$

but further investigations must decide this point.

A hot solution of parabanic acid in presence of free sulphuric acid is readily oxydized by potassic hypermanganate. In three experiments, 114 milligrams of parabanic acid required 53·3, 53·3, 53·5 c. c. of a solution of the hypermanganate, of which 53·6 c. c. contained 16 milligrams of available oxygen. This is exactly one atom of oxygen for one molecule of paraban. The oxydizing action of the hypermanganate is probably represented by the equation

$$\mathrm{C_3H_2N_2O_3 + 2H_2O + O = 3CO_2 + 2NH_3}.$$

I consider it certain that parabanic acid is directly oxydized by potassic hypermanganate and not after previous conversion into oxaluric acid, as I shall show that this last can only with extreme difficulty be oxydized in an acid solution.

Action upon oxaluric acid.—Potassic nitrite in presence of free acetic acid acts readily upon oxaluric acid with effervescence. After long boiling only oxalic acid is to be detected in the solution. The effervescence arises evidently from the decomposition of the urea, the oxaluric acid being converted by boiling into oxalic acid and urea, which last is decomposed as fast as formed.

Potassic hypermanganate oxydizes oxaluric acid in an acid solution with great difficulty, and no well defined end reaction can be observed. The same remark applies to alloxan, alloxantin, and generally to all bodies belonging to the uric acid

series of which urea is one of the products of decomposition in presence of water.

Dialuric acid.—Pure colorless crystals of dialuric acid, obtained by boiling alloxantin with zinc-dust and small quantities of chlorhydric acid, were treated with potassic nitrite and acetic acid. Strong effervescence ensued and on cooling beautiful colorless prismatic crystals separated in abundance. After repeated recrystallizations the crystals were burnt with oxyd of copper.

0·6984 gr. gave 0·2462 gr. water and 0·7694 gr. carbonic acid = 30·27 per cent carbon and 3·91 per cent hydrogen.

0·6730 gr. gave 189 c. c. nitrogen at −1° C. and 761·5^{mm} = 35·40 per cent nitrogen.

		Calculated.	Found.
Carbon	4	30·38	30·27
Hydrogen	6	3·80	3·91
Nitrogen	4	35·40	35·40
Oxygen	3	30·42	----
		100·00	

The results of these analyses agree perfectly with the formula, $C_4H_6N_4O_3$, of allantoin, with which the substance corresponds in all its properties. In the mother-liquor from the allantoin I detected no other organic body. It is therefore most probable that the reaction resulting in the formation of allantoin from dialuric acid is expressed by the equation

$$\underset{\text{Dialuric acid.}}{2C_4H_4N_2O_4} + 2N_2O_3 = \underset{\text{Allantoin.}}{C_4H_6N_4O_3} + 4CO_2 + H_2O + 2NO + 2N.$$

I am not aware that allantoin has hitherto been obtained from dialuric acid. Murexid is not sensibly acted upon by the alkaline nitrites in presence of acetic acid, even by long boiling.

My investigation of the products of the action of nitrous acid upon uric acid and its derivatives was nearly completed when I became acquainted with the memoir of Sokoloff * upon the same subject. By the action of nitrous acid upon uric acid, Sokoloff obtained a new acid to which he has given the name of urinilic acid, and to which he ascribes the formula $C_8H_7N_7O_6$. I have not observed the formation of this acid, but will simply remark that the Russian chemist appears to have studied the action of nitrous acid under wholly different conditions, so that the diversity of his results is easily accounted for. The difference between the properties of urinilic and stryphnic acids is too great to permit even a suspicion of their identity. My acknowledgments are due to Mr. W. N. Hill for most efficient aid in the prosecution of my work.

Cambridge, June 15th, 1869.

* Zeitschrift für Chemie, Bd. v, p. 78 (3d Heft June, 1869.)

Art. XXIV.—*Account of the Swedish North-Polar Expedition of* 1868, *under the command of* A. E. Nordenskiöld *and* Fr. W. von Otter.*

The study of the natural history of the polar regions has been of late years prosecuted in Sweden with so much interest that, exclusive of the present year's undertaking, no less than three† separate expeditions have been sent out from this country to the arctic seas. When Nordenskiöld last winter again brought forward a proposal for a new expedition, on a different plan, which was to set out in the autumn from the northern coast of Spitzbergen and penetrate farther northward, the means requisite to defray the expenses of the expedition were in a few days raised in the second city of Sweden, Göteborg [Gottenburg], at the instance of the resident governor, Count Ehrensvard. When, moreover, the Government, in order to assist the undertaking, fitted out and manned the steamship *Sofia*, well adapted for the purpose, strongly built of Swedish iron, and originally intended to carry the mails over the Baltic in winter, the new expedition was enabled to assume a more extensive character and embrace a wider compass than had originally been intended. Most expeditions of this kind have had for their object to attain as high a degree of north latitude as possible ; but a glance

* Extracts from the full report, here reprinted from the Minutes of the Royal Geographical Society of the meeting March 22, 1869.

† These were the following:—

The Expedition of 1858, fitted out at the expense of Otto Torell. The following gentlemen took part in the undertaking: O. Torell, A. E. Nordenskiöld, A. Qvenuerstedt. The Expedition visited the western coast of Spitzbergen, and brought home considerable zoological and geological collections.

The Expedition of 1861, fitted out at the public expense. The gentlemen who took part in the expedition, besides the proposer and chief, O. Torell, were A. Von Goës, A. T. Malmgren, F. A. Smitt, G. Von Yhlen, zoologists and botanists; B. Lilliehöök and W. Kuglenstjerna, commanders of the vessels; C. W. Blomstrand, C. Chydenius, N. Dunér and A. E. Nordenskiöld for geological and physical investigations. The expedition visited, in both vessels, the western and northern coasts of Spitzbergen, made extensive journeys in boats for the purpose of constructing a topographical and geological map of the group of islands, and of examining the northern part of the triangulation for degree-measuring, which the present President of the Royal Society, General E. Sabine, as early as 1826, proposed to get executed, in these high northern regions ; and lastly brought home with them a collection of materials for studying the *fauna*, *flora*, and geology of the islands, probably not surpassed in completeness by any similar collections from districts situated at so great a distance from the centers of civilization.

The Expedition of 1864, fitted out at the public expense, chiefly for the purpose of continuing the survey for the measurement of the degree. The gentlemen who took part in the undertaking were A. E. Nordenskiöld, chief, N. Dunér and A. J. Malmgren. The expedition visited the southern part of Spitzbergen and Storfjord, completed the survey for the degree-measuriug, and brought home rich geological, zoological and botanical collections.

at their history will convince us how difficult and uncertain the attainment of this object is, and how frequently an insignificant circumstance has obliged the, in other respects, best planned expeditions to return without any scientific result whatever,—a contingency which there would have been no reason to apprehend if proper care had been taken in the scientific furnishing and manning of the expedition. In order to remove all fear of the new Swedish expedition having a result of this kind, it was determined that in this, as in the preceding Swedish arctic expeditions, a continuation, as general as possible, should be made of the researches in natural history commenced by their predecessors. For this purpose the expedition was provided, by the Royal Academy of Science in Stockholm, with a carefully-selected and appropriate scientific apparatus,* and was accompanied by as numerous a body of professional scientific men as room and circumstances permitted.

The plan of the journey was, during the summer and early part of the autumn, to pay a visit in the *Sofia* to Beeren Island and Spitzbergen, and carefully examine both the marine and terrestrial fauna of these lands; their flora, both phanerogamous and cryptogamous, as also their geography and geology. It was also intended to make deep soundings, and to take meteorological and magnetical observations, &c. A supply of coal was to have been deposited by a ship, hired for that especial purpose, at some fitting spot on the northwest corner of Spitzbergen, which is accessible till late in the season; which tract the *Sofia* was accordingly to visit during the course of the autumn, and whence some of the scientific men were, in the beginning or middle of September, to return in one of the colliers to Norway. The rest were to endeavor, in the *Sofia*, to make their way farther north, and, if necessary, to pass the winter (circumstances permitting) in some appropriate harbor of the Seven Isles, which form the Old World's most northern archipelago.

The gentlemen who took part in the expedition were:—*Geologist*,—A. E. Nordenskiöld;† *Captain*,—Fr. W. v. Otter, R. SW. N.; *Lieutenant*,—A. L. Palander, R. SW. N.; *Physician*,—C. Nyström; *Natural Philosopher*,—S. Lemström; *Zoologists*,—A. E. Holmgren, A. J. Malmgren, F. A. Smitt; *Botanists*,—Sv. Berggren, Th. M. Fries; *Geologist*,—G. Nauckhoff.

* The London Royal Society and the University of Helsingfors contributed to the instrumental apparatus of the expedition.

† The geographical and hydrographical researches were to be performed by Nordenskiöld, von Otter and Palander. These last—of whom, in consequence of their office, one was almost always on board—also took upon themselves the meteorological observations. Nyström assisted the zoologists, and also directed his attention to the remarkably interesting hygienistic features of these regions.

The vessel was manned by fourteen seamen, together with the zoological conservator Svensson, and six dredgers, hired in Norway. The ship placed at the disposal of the expedition having been under the inspection of Captain von Otter, duly fitted out in Carlscrona, and furnished with provisions for something more than a year—or, when account is duly made of the game that in these parts one may always reckon upon, for about a year and a half—and touched at Göteborg to take on board the scientific apparatus and the men of science who took part in the undertaking, anchor was weighed on the 7th of July. The 16th -20th Tromsö was visited for the purpose of taking in coal, &c.

On the 22nd the *Sofia* cast anchor in the southern harbor of Beeren Island, where some members of the expedition landed to study the natural phenomena of a place difficult of access on account of the want of a good harbor; while the remainder continued on board the vessel, which cruised in the neighborhood, and occupied themselves with soundings and with an examination of the local marine fauna.

The expedition left Beeren Island on the 27th of July. Our course was directed to the eastern coast of Spitzbergen, which had not been visited by any of the previous Swedish expeditions; but already at South Cape we met with ice, which, as we approached the Thousand Isles, became more and more abundant, and we were obliged to turn back. After some hesitation as to whether we should wait at South Cape till the water became more free from ice, in order to proceed farther eastward, or immediately begin the scientific operations on the west coast of Spitzbergen that entered into the plan of the voyage, we embraced the latter alternative; and it was very fortunate that we did so, for on our return home we learned that the east coast, during the whole summer of 1868, had been rendered completely inaccessible by the ice.

Our course was now directed to Ice-fjord, where the *Sofia* cast anchor on the morning of the 31st of July. We continued a fortnight in the different harbors of that extensive fjord, and penetrated, in our boat-excursions, to the innermost parts of the fjord's northern arm, which had not previously been visited by the Swedish expeditions. During this time all the members of the expedition were busily occupied in scientific researches, and in collecting objects of natural history. The change was, indeed, advantageous, as well for our zoological and botanical as especially for our geological investigations.

The previous Swedish expeditions had pretty fully explored the principal features of the geology of Ice-fjord, and had found it, in consequence of the varying strata on its shores, full of different types both of animal and vegetable remains, and un-

usually rich in materials illustrative of the geological history of the extreme north. Innermost in the fjord are found immense beds of red clay-slate, and sandstone, probably Devonian, which, however, do not here contain fossils. On them lie strata of limestone, gypsum and flint, filled with large coarse-scaled mountain-limestone brachiopoda; then come *Trias* beds, with large nautilus-forms and remains of saurians; after these, *Jura* strata with *ammonites;* then *Tertiary* strata, in many places rich in plant-impressions, indicating a former temperate climate; and, lastly, scanty remains of *Post-tertiary* strata, with plant-fragments and sub-fossil marine shells, *some of which now first occur in living condition in the northern parts of Norway.* The preceding Swedish expeditions had brought home specimens from all these strata;* not, however, sufficiently numerous to give a geological representation of the place's former history so complete as the importance of the subjects requires. To supply this defect was one of the chief objects of the expedition of 1868; and we succeeded in bringing home unusually rich collections, especially of plant-impressions and Trias petrifactions, which, when duly studied, will, no doubt, throw much light on the condition of the climate and arrangement of the land of the arctic regions at that remote period.

Spitzbergen, as is generally known, is at present frequently visited by Norwegian ships engaged in walrus and seal fishing, or in fishing for the "haakjoering" (*Scymnus microcephalus*) on the banks beside the island's coast. The walrus is, however, now but very rarely met with on the western side of Spitzbergen; and its fjords are therefore only occasionally visited for the purpose of taking in water or hunting the reindeer. On how large a scale the hunting of these animals may be carried, is evidenced by the circumstance that the vessels fitted out from Tromsö alone in 1868, according to official returns, killed 996 head. From Hammerfest the returns are still greater; whence we may conclude that, in spite of the war of extermination which, under the name of hunting, has for some time been carried on against these animals, two or three thousand head are annually slaughtered. If we compare that number with the scanty extent of ice-free meadow-land in Spitzbergen, we are tempted to suppose that an immigration must take place from Novaja Zembla, which, nevertheless, is

* The first mountain-limestone petrifactions in Spitzbergen were found by Parry in 1827 at Cape Fanshawe, and the same year by Keilhau at South Cape. Jura fossils were first discovered by Lovén in 1838; the tertiary plant-remains by Nordenskiöld in the Swedish expedition of 1858; the Trias strata by Blomstrand in 1861; the post-tertiary beds, containing Mytilus, by Torell, Malmgren and Blomstrand in 1861; the Saurian strata by Nordenskiöld in 1864.

scarcely possible, unless some large island or group of islands facilitates the communication between these two countries, situated at a distance of between 400 and 500 nautical miles from one another. Of late years the Norwegians have resumed the method, formerly employed by the Russians, of using large nets, formed of rope, to catch the Beluga (*Delphinopterus leucas*); and in 1868 several vessels were fitted out exclusively for that species of fishing. Some of the fishermen whom we met had, on one or two occasions, taken from twelve to twenty head at a single drag of the net: right handsome sport, when one considers that the *Delphinopterus* is often larger than the walrus itself.

Ice-fjord, like most of the other gulfs of Spitzbergen, is surrounded by vast glaciers with their mouths turned toward the sea, which offer to the geologist an opportunity of studying that phenomenon so important in the history of the earth's development. But extensive valleys or declivities free from ice and snow are also met with, especially in the inner parts of the fjord, and the fertile soil here produces a vegetation more luxuriant than in other parts of this island group. One may here see whole fields yellow with poppies (*Papaver medicante*), or covered with a thick green and red carpet of the beautiful *Saxifraga oppositifolia*. The fjord, which lies beneath them, and in the summer months is often as still and clear as a looking-glass, abounds with marine animals of various kinds. Everything contributes to make this a most important spot for the study of both animal and vegetable life in the Arctic regions. The zoologists and botanists of this expedition here gathered a rich harvest; among the results of which we may mention the taking of several fine salmon, and fully-developed examples of the esculent mushroom, &c.

We left Ice-fjord on the 13th of August. At the entrance a boat-party was sent out northward, to map and examine geologically Foreland Sound. Their work was now—as during the expedition of 1861, when Blomstrand and Dunér sailed through the sound—rendered difficult by almost perpetual fog. During this time the vessel made a somewhat longer excursion westward for the purpose of taking soundings; which, however, were on the occasion rendered almost impossible by the heavy swell. We had arranged to meet at King's Bay, whither both parties came on the 17th, in the afternoon. Several zoological, botanical, and geological excursions having been made from this point, and a large number of miocene fossil plants collected, the *Sofia*, on the 19th, proceeded on her course farther northward.

We had hoped here, in some degree at least, to reinforce our already considerably diminished stock of coal, but we soon found that that would necessarily cause too great a delay. In fact, whereas, more to the south, the tertiary formation occupies the greater part of the extensive peninsula between Icefjord and Bell Sound, and there in many places forms mountains above a thousand feet high, at King's Bay, on the contrary, its extent is very inconsiderable, so that at present it forms only a few small hills consisting of strongly-folded strata, and separated from each other by the furrows cut by the glacier-streams. By this the supplies of coal, notwithstanding the thickness of the beds by no means inconsiderable and their accessibility (they lie only a few hundred feet from the shore of one of the best harbors in Spitzbergen), become of but little value, especially as the frost, which begins at a very short distance under the surface, renders the breaking of them extremely difficult; in fact, in consequence of the extreme toughness of the ice-drenched coal, almost impossible without regular mining. It is even to be expected that the whole of what still remains of the miocene formation of this spot will, in a comparatively short period, be washed away.

Late at night, on the 20th August, the *Sofia* anchored at Amsterdam Island, and the following day we had the pleasure of hailing the first of the ships which had been hired in Norway for the expedition for the transport of coals. A coal depôt having been established on the low tongue of land that shoots out south-eastward from Amsterdam Island, and five of the scientific members of the expedition having been landed at Kobbe Bay, together with the necessary tents and boats, to prosecute their zoological, botanical, and physiological researches, the *Sofia* sailed off with the rest on a sounding-tour toward Greenland. Our intention was to penetrate thither along the 80th degree of N. latitude, but before we had reached the longitude of Greenwich we were met by impassable masses of drift-ice. It was evident that the coast of Greenland was accessible only at a latitude much lower than was compatible with the plan of our voyage. We therefore turned our course north and northeast, and gradually, after innumerable zigzags in the ice, arrived at 81° 16′ N. latitude. The temperature had now sunk to 6° (centigr.), with thick ice, fogs, and snow-storms. The ocean was sometimes covered with a thin coating of new ice, and the old ice northward was quite impassable, so that we were obliged to seek a passage out in a southeasterly direction. After another vain attempt to reach Depôt Point, in Brandewijne Bay, the *Sofia* anchored, on the 29th, in Liebde Bay.

During the passage of the *Sofia* from Norway to Spitzbergen, its officers, Captain Baron von Otter and Lieutenant Palander, took a number of soundings in the deeper parts with a "Bulldog" apparatus of the same kind as that constructed at Tromsö, by Torell and Chydenius, for the voyage of 1861, and which was found to be particularly applicable. These soundings were zealously continued during our cruising amid the drift-ice between 80° and 82°, and gave very interesting results not only as regards the ocean's depth in the parts visited by us, but also concerning Arctic animal life at the greatest measurable depths. It showed us that Spitzbergen may in a manner be looked upon as a continuation of the Scandinavian peninsula, inasmuch as that island-group is not separated from Norway by any very deep channel (not above 300 fathoms), whereas a little to the north and west of Spitzbergen there is a depth of 2000 fathoms and more. From these great depths specimens of clay were brought up by the Bulldog-apparatus, which, on immediate and close examination, were found to contain not only several microscopic, but even larger and tolerably highly-organized animal forms (*e. g.*, several kinds of Crustacea and Annellata). The greatest depth from which any specimen was procured was 2,600 fathoms, and the mass there raised consisted for the greatest part of white and red Foraminifera, in general scarcely as large as a pin's head. It is, moreover, deserving of remark, that, during our cruisings amidst the ice, we met with and collected, not only a number of pieces of drift wood, but also (as, for example, at 80° 40′ E.) glass balls of the kind used by the Norsemen, at their Loffoden fisheries for floats; an additional proof of the already well-established fact,* that the Gulf Stream reaches, though in a greatly weakened state, even these tracts.

Liebde Bay had never before been visited by any scientific expedition, and its topography and geology were accordingly entirely unknown. A boat-party, consisting of Malmgren, Nordenskiöld, and Nyström, with three men, were therefore left here, while the ship went to fetch their comrades who had been left at Kobbe Bay. The boat's journey was favored with calm and mild weather and a clear sky; although a high wind, accompanied by snow-storms, prevailed out at sea—a circumstance very common at Spitzbergen, and which is said especially to characterize that beautiful, and, according to the unanimous testimony of the fishermen, appropriately named, fjord. We

* Among the proofs of this already given may be mentioned, that Torell, in 1861, at Shoal Point, met with a bean that had come from the Gulf of Mexico, the *Entada gigantilobium*.

were thus enabled, during the few days that our boat-voyage lasted, to map it, and ascertain the character of its somewhat uniform geology. Its shores are occupied exclusively by the same red, green, and dark grey kinds of slate, which in Icefjord are covered by mountain-limestone strata with *Producti*, and in Mount Hecla form the uppermost stratum of the vast series of schists to which the name of that mountain has been applied. But, as yet, no petrifications had been discovered in these strata. Their age was accordingly somewhat doubtful, and the probably Devonian fish-remains which we now found here are therefore a discovery of great value in the explanation of Spitzbergen geology. The lower slatebeds contained some vegetable remains, though probably of too indistinct a character to admit of identification.

On the 2nd of September, the boat's company and the ship, returning with our comrades from Kobbe Bay, met at a little distance off the promontory that separates Wijde Bay and Liebde Bay. After remaining in that bay a couple of days longer, the *Sofia* weighed anchor and touched at the now ice-free Cape Depôt, in Brandewijne Bay, in order to fetch away the supply of pemmican that (in 1861) had been left there, an iron boat, &c. We thence steered northward, with the intention of passing round Nordostland to Giles' Land. The greater part of the arm of the sea, that lies between the Seven Islands, Cape Platen and North Cape, which, in 1861, was already, in the middle of August, perfectly free from ice, we now, in the beginning of September, found covered with a firm crust of ice. It was therefore impossible to reach Giles' Land by this route, and we were therefore obliged, after having for the purpose of botanical and zoological researches, remained a short time a Castién's Islands and Parry's Island, which last, being still encompassed by a girdle of land-ice, was approachable only walking over the ice, to seek another passage, namely, that through Hinloopen Strait. Our course was directed to its southern part.

Already, before the end of September, some signs of the approach of autumn had been visible, and the hill-tops had frequently in the morning been for some time covered with a white mantle of new-fallen snow, which, however, had melted away again without causing any hindrance to our scientific pursuits. But now, during our passage to South Waijgats Islands, a copious fall of snow rendered all further researches in natural history on land impossible, and gave us pretty clearly to understand that the season for our purely scientific pursuits was to be considered as at an end. We accordingly turned back at Mount Lovén, in the southern part of Hin-

loopen Strait, having first on that spot collected, from under snow of a foot deep, an additional number of mountain-limestone petrifactions. On the 12th of September we again anchored at our coal depôt on Amsterdam Island, and there met our second coal-ship, by which some of the members of the expedition (Fries, Holmgren, Malmgren, Nauckhoff, and Smitt) returned to Norway, carrying with them the valuable collections of objects of natural history which the expedition had up to that time succeeded in acquiring. These collections have now safely arrived in Stockholm, and will, after having been duly studied, be divided between the National Museum in that city, where already the extraordinarily rich Arctic collections formed by the preceding Swedish expeditions are preserved, and the Museum of Göteborg, the city whose liberal initiative first gave occasion to the new expedition. To give an idea of the extent of these collections, I need only refer to the notices above given of our geological operations, and remark that the zoological sciences were represented by no less than three members of the expedition, who, besides, had with them a taxidermist. Messrs. Malmgren and Smitt had also at their disposal a boat manned with four men for dredging every day, holidays excepted, when the ship lay still. They were thus enabled not only to make a searching examination of the Arctic marine fauna, which, in individual copiousness at least, is comparable with that of many more southern countries, but also to pay due attention to the terrestrial fauna of the locality, more especially the entomological branch, which is poor both with respect to individuals and species, and accordingly presented especial difficulties to its investigator, Mr. Holmgren. The dredgings also yielded rich contributions to the ocean's algaflora. Every opportunity that offered itself for land-excursions was used by the two botanists of the expedition, both for investigating the flora and for forming a collection of specimens for normal herbaria of Spitzbergen's phanerogamia, mosses, lichens, and algæ.

On the 16th of September we took leave of our homeward-bound companions, and immediately proceeded northward. Our intention was to touch at the Seven Isles, but these were now found to be still more thickly surrounded by ice than when we had visited that tract about a fortnight before. We accordingly determined to avail ourselves of a channel tolerably free from ice, stretching northward from those islands.

After a number of zigzags amidst the drift-ice, our vessel, in longitude 17½° east from Greenwich, succeeded in arriving at 81° 42′ north latitude, probably the highest northern latitude a ship has ever yet attained. Northward lay vast ice-

masses, it is true as yet broken, but still so closely packed that not even a boat could pass forward, and we were therefore obliged to turn to the southwest and seek for another opening in the ice; but we found, on the contrary, that the limit of the ice stretched itself more and more to the south the more we went to the west, so that, on the 23rd September, in the longitude of Greenwich, we were south of the parallel of 79° N. latitude. On the way we had in several places met with ice black with stones, gravel, and earth, which would seem to indicate the existence of land still farther north.

The ice itself had, moreover, a very different appearance from that which we had met in these tracts at the end of August. It consisted now, not only of larger ice-fields, but also of huge ice-blocks, so that it seems as if the former ice had drifted to the south, and given place to new ice-masses coming from the north. The temperature had now sunk to 8° or 9° (centigr.) below the freezing point, and the ice, which in these parts had before been of tolerably loose texture, had now become so compact that any more violent collision with it was combined with no little danger. Furthermore, the nights were now so dark, that it was necessary at that time to lay the ship to by the side of some large sheet of ice, at the hazard of finding ourselves blocked up there in the morning. Already, in the beginning of September, the surface of the ocean, after a somewhat heavy fall of snow, had shown itself, between the ice-masses, covered with a coating of ice, which, however, was then thin, and scarcely hindered the vessel's progress. Now it was so thick that it was not without difficulty that a way could be forced through it. All things clearly indicated that the season of the year, during which it is possible to sail in these tracts, was nearly at an end, and as we intended to make yet another attempt to find a northern passage from the Seven Isles, or seek a harbor for the winter, we determined to return to our coal-depôt.

On the 25th of September the *Sofia* once more cast anchor at the north-west corner of Spitzbergen, after having slightly struck upon a rock situated under the surface of the water in the middle of South-gat, and which has been forgotten in Buchan and Franklin's admirable chart of the harbor, although it appears, from Beechy's description, that they themselves happened to strike on the same shallow.

After a few days' rest, spent in inspecting the engine and taking in coal (the last remains of our store of coals had to be seached for under a thick covering of snow), and after having placed in the letter-box on the island in Kobbe Bay notices of our journey and our plans for the future, we steamed away

again, on the 1st of October, northward, notwithstanding a strong wind and a snow-fog that prevailed in the harbor we left. Our suspicion that this was only local seemed to be confirmed when we got out a little farther north, as the weather became clearer and calmer, but at the same time we met already, in lat. 80° 40′, sporadic blocks of drift-ice, which, as we proceeded farther north, increased in number and size. We continued our northward course during the following day, but it was soon evident that no open water would be arrived at that way, and in the afternoon we were again steering in a southerly direction. During the night we lay to under cover of a large sheet of ice. The temperature had now sunk to 14° 5′ (centigr.) so that in calm weather the surface of the water between the ice-masses was covered with ice of two or three inches' thickness, which considerably impeded the progress of the ship. But the following day we stood southward till we got into something like open water, and then followed the edge of the ice in a northerly and northwesterly direction. By this means we again arrived at 81° N. lat., but here the *Sofia* met with a misfortune which put an end to all further efforts to proceed northward. In the morning of the 4th October, during a storm from the southeast, and with a high sea, the ship was thrown violently upon a huge ice-block, or rather a small iceberg, whereby she sprang an extensive leak. We were therefore forced to turn back immediately and seek our harbor, where we arrived late in the evening, after eleven hours of incessant labor to keep the vessel free from water. Nevertheless, though all took part in this work, the water continually rose, so that, when the anchor was cast at Amsterdam Island, it stood about two feet over the cabin floor. Fortunately the provisions, being kept between water-tight bulkheads, were uninjured, and we succeeded, though with great difficulty, in keeping the engine-room so free from water that the fires were not extinguished. Had this not been the case, our ship must unquestionably, in a short time, have been the prey of the storm and the extremely heavy sea, which now, contrary to our former experience, raged among the thinly-scattered fields of drift-ice. Immediately on our arrival at Amsterdam Island the ship was careened and the leak provisionally stopped, so that already the next day we were in a condition to seek a more secure harbor in King's Bay. Here the ship was hauled so close to land at flood, that we, at ebb, were enabled to come at the leak and stop it effectually.

King's Bay, which in summer time is almost free from ice, was now filled with innumerable ice-blocks fallen from the mighty glaciers of the fjord, which, when carried by the flood-

tide in toward land, totally barricaded the barbor in which the *Sofia* had taken refuge ; and, notwithstanding that the temperature here was considerably higher than in the neighborhood of 81° N. lat., these blocks froze during the calm weather so fast together, that when we on the 12th of October, were again in a condition to sail, it was only with the utmost difficulty that our vessel could get out.

Our stay in King's Bay, like all the preceding occasions on which the ship remained any length of time still, was taken advantage of by our natural philosopher Dr. Lemstrom, for the purpose of making observation for the determination of the magnetic constants and variations. The ground was, however, too deeply covered with snow to allow of any geological or botanical operations. Even the brooks, so copiously supplied with water in the summer time, which intersect the lowlands adjoining the coal harbor, were now so entirely dried up by the effect of the cold that we endeavored in vain to reinforce our now considerably reduced supply of water.

Our ship, which had had two ribs broken by the blow that caused the leak, was now too weak to be exposed, with the slightest prospect of success, in any new attempt to force a way through fields of drift-ice, as would in all probability be necessary, should we endeavor to visit the Seven Islands, which place we had intended to make our winter harbor ; and the wintering in any other part of Spitzbergen not having entered into our plan, nor promising results commensurable with the costs, dangers, and hardships, we determined to return to Norway. But yet we wished to make an attempt to reach Giles' Land round the southern point of Spitzbergen, which was probably still free from ice. Already during our passage along the west coast of Spitzbergen, which in summer is entirely free from ice, we passed large, though scattered, fields of ice, which farther to the east, near the Thousand Isles, completely obstructed the way. We were, therefore, constrained to relinquish that plan also, and to direct our course toward Norway. After having been once more, on the shallow banks off Beeren Island, during a severe storm and in a high sea rendered to the last degree boisterous by the shallowness of the water, in great danger of being ice-beset, the *Sofia* anchored again on the 20th of October in Tronsö Harbor, where we had the pleasure of learning that our comrades had happily arrived and reached home in safety.

From the above it appears that the expedition, as regards its second object—namely, hydrographical investigations in the Polar Basin—did not succeed in reaching any remarkably high

degree of latitude; so that the portion of our globe that is known to us has not been to any material amount increased by it. I hope, however, that it has afforded a by no means unimportant contribution to the solution of the so-called Polar question.

A lively controversy has, as is generally known, been of late years carried on between the principal geographical authorities concerning the real character of the Polar Basin, some geographers maintaining that it is covered by an unbroken surface of ice, presenting an impassable barrier to the progress of a ship; while others look upon this as only an obsolete prejudice, arising in a great measure from exaggerated descriptions of the difficulties which the sailor encountered at the point where he turned back. That this latter view, at least as regards that portion of the Polar Basin that borders on Europe during the actual sailing-season in the Northern Seas, *i. e.* the summer, is not in conformity with the real fact, has been proved, not only by the adventurous journeys of the older Arctic travelers, but by a number of expeditions sent out during the last century for the exclusive purpose of such investigations, among which may be mentioned:—

Tschitschagaff's 1st expedition, 1765, which with their ship could reach only			80° 21′	N. lat.
" 2nd "	1766,	which reached	80 28	"
Phipps "	1773,	"	80 37	"
Buchan and Franklin's "	1818,	"	80 34	"
Scoresby's "	1806,	"	81 30	"
Sabine and Clavering's "	1823,	"	80 20	"
Parry's "	1827,	"	81 6*	"
Torell's "	1861,	" about	80 30†	"

It might then have been considered as already absolutely decided that it was not possible at that season of the year to penetrate very far into the Polar Basin, and any repetition *at the above-named season of the year* of these attempts could therefore only be looked upon as continually treading in old footsteps, which demonstrably do not lead to the intended object. But one doubt remained. At the season of the year when, in consequence of the heat of the summer and the influence of the ocean-waves and ocean-streams, the ice-masses have been reduced to their minimum—that is to say, in the autumn, before the formation of the new ice, no ship had ever before visited the Polar Basin. We could with certainty foresee that it might then be possible to go farther than in summer. There was a possibility that we might at that season be able to penetrate very far, perhaps to some land lying north of Spitz-

* By ship, but on the ice the party penetrated to 82° 45′.
† By ship, but in boats and by land journeys as far as 80° 45′.

bergen, which might hereafter serve as base from whence to push still farther onward. These considerations constituted the ground for the plan of operations for the latter portion of the Swedish expedition, and it may now be considered as proved, that a ship may, during autumn, reach a latitude considerably higher than that which has been attained by most of the summer expeditions. Unless this year is to be considered as unusually unfavorable with regard to the condition of the ice, we might in all probability have proceeded a considerable distance farther, perhaps beyond 83° N. lat. But we have at the same time convinced ourselves that, even in autumn, farther progress is soon rendered impossible by impenetrable masses of broken ice. The voyage itself, moreover, at that season of the year, in consequence of the cold, the darkness, and the boisterous winds, accompanied by snow-storms that are then prevalent in the polar basin, and the heavy sea amidst the masses of drift-ice caused by these latter, is rendered so dangerous that the risk to which the traveler exposes himself is far from being compensated by the meager prospect of success. The idea itself of an open polar sea is evidently a mere hypothesis, destitute of all foundation in the experience which has already by very considerable sacrifices been gained; and the only way to approach the pole, which can be attempted with any probability of success, is that proposed by the most celebrated arctic authorities of England, viz., that of—after having passed the winter at the Seven Islands, or at Smith Sound—continuing the journey toward the North on sledges in the spring.

ART. XXV.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXI.—*On the Meteoric Stone which fell Dec. 5th,* 1868, *in Franklin Co., Alabama;* by GEO. J. BRUSH.

IN a letter addressed to the editors of this Journal, dated Tuscumbia, Ala., Dec. 22d, 1868, Mr. Benjamin Pybas stated that an aerolite weighing 1 lb. 9½ oz. had fallen four miles south of Frankfort, in Franklin Co., Ala., on the 5th of December. Subsequently, through Mr. Pybas's influence, the stone was sent to me for examination. Mr. Pybas has taken great pains in collecting all the facts connected with the fall, as will be seen by the following abstract from a letter received from him in March last.

"The meteorite fell Dec. 5th, 1868, four miles south of Frankfort, the county town of Franklin County, Alabama. The country around Frankfort is broken and hilly, being the termination of the western branch of the Cumberland Mountains. Frankfort is sixteen miles southeast of Tuscumbia.

"Mr. James W. Hooper witnessed the fall and describes it in a note to Dr. T. D. West, which I copy. 'About 3 o'clock, P. M., the afternoon being cloudy and cold, we heard a strange, harsh, roaring noise up in the air. Three distinct reports were heard; at first these were supposed to be cannon, but the noise immediately changed into a series of bursting sounds, like a great fire blazing and crackling through the air. It appeared to pass from the north toward the south. Immediately after the first sound or roaring had passed over, another was heard coming from the same direction, like the whizzing of a bomb-shell as it cuts through the air, making a loud humming noise. I gazed intently in the direction of the noise and found that something was coming downward at a rapid rate. I looked, with my hand up, standing in a dodging position, for fear of its striking me, until I saw it strike some willow saplings about seventy or eighty yards from where I was and fall thence to the ground. Upon going to the spot I found a strange looking rock, nearly buried in the ground and still warm.'

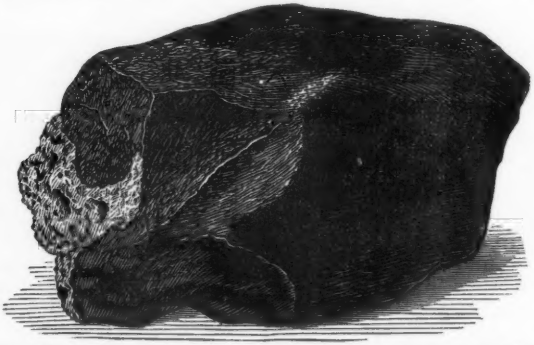
"Major Slass, editor of "the Alabamian and Times" in this place, has taken considerable trouble to collect all the information he could on the subject. He says, 'that the noise was heard for several miles around, before the final explosion. It burst, apparently, over the heads of twenty men, who were at work felling wood, one and a quarter miles from Mr. Hooper's house. One piece appeared to go southeast, another southwest, and the third northwest. There were afterward heard the reports resembling the bursting of shells. One piece was heard to fall some distance from Mr. Hooper's, making a loud, crashing noise and frightening a lot of hogs near by.'

"The reports resembling artillery were plainly heard for twenty or twenty-five miles east and west of Frankfort, and from fifteen to twenty north. I have no information as to the south. Mr. Hooper deserves much credit for noting the particulars of the fall, and for sending the meteorite for analysis and description. He refused with scorn, money offers that must have been tempting to a person of limited income, preferring the advancement of science to dollars and cents.

"In a personal interview, he told me that he was sitting by a fire with his family when he heard the first noise. He instantly arose and walked forty or fifty yards from the house before the meteorite fell. His sister, Miss Hooper, living near,

called to her brother to 'run quickly, the house is on fire—don't you hear it?' Mr. H. thinks it was three or four minutes from the first noise until its fall. The place where it struck the ground is a partially decomposed conglomerate, mixed with vegetable mould. The fracture was made by striking a fragment of limestone rock."

When received by me the meteoric stone weighed 615 grams. The crust was entire with the exception of a small corner, although the whole mass seemed to have a fresh fracture running through it. The weight of the entire meteorite could not have been over 650 grams. The accompanying cut will serve to



give some idea of its general outline; it is drawn half the actual size of the stone. The coating has a very brilliant luster, as bright as if newly varnished, strongly resembling that of the Stannern, Petersburg, Tenn., and Bishopville stones. It seems to have been in a condition of viscid fusion as shown by the ridges on the edges represented by the white lines. The crust was so thin in some parts that fragments of olivine could be distinguished through it.

On the fractured surface, as seen by the naked eye, it presented a pseudo-porphyritic structure, having a gray ground with black, green, white and dark gray spots upon it. A careful microscopic, mineralogical, and blowpipe examination of the different parts was made, with the following results: 1. The *black* mineral was coal-black, brightly lustrous and slightly magnetic; B.B. difficultly fusible and became more magnetic; on treating with the fluxes it reacted for chromium and iron; it proved to be *chromite*. 2. The *white* mineral fused with difficulty to a transparent glass, reacted for silica and soda or lime. I could not determine whether it was *chladnite* or anorthite; it seemed too difficultly fusible for labradorite. 3. A *yellowish green* mineral passing into *yellow* and also apparently

shading into *dark gray*; this was fusible with difficulty on the edges and became magnetic on heating; the green mineral appeared to be olivine, but the gray had also the same pyrognostic characters, while in physical characters it cannot be distinguished from Haidinger's *Piddingtonite*, found in the Shalka meteoric stone. 4. The lens revealed brilliant points with metallic luster, which on examination proved to be sulphid of iron (*troilite*). 5. One or two delicate black veins were observed with the glass which were at first supposed to be schreibersite, but I was unable to detach enough for a blowpipe test, and a careful qualitative examination showed no traces of phosphorus. 6. On pulverizing several grams of the stone I found a few flakes of niccoliferous iron, amounting in all to a few hundredths of one per cent of the mass.

The specific gravity of the stone in four determinations gave 3·35, 3·33, 3·31, 3·26, the mean being 3·31.

An attempt was made to separate the different silicates by the action of chlorhydric acid. It was found, however, that only about 26 per cent of the mass was soluble in acids, and the bases in the acid solution and in the insoluble portion were the same, save that the insoluble contained all the *chromite*. A complete analysis of the meteorite was made by fusion with carbonate of soda with a small amount of nitrate of soda to effect the oxydation of the chromium and the sulphids and metallic substances present. The alkalies were determined by Smith's method. The results of the analysis, commenced by myself but completed by Mr. Wm. G. Mixter, were as follows:

		Oxygen.	
Silica,	51·33	26·37	
Alumina,	8·05	3·75	
Ferrous oxyd,	13·70	3·04	
Chromic oxyd,	0·42		
Magnesia,	17·59	7·04	12·28
Lime,	7·03	2·06	
Soda,	0·45	·11	
Potash,	0·22	·03	
Sulphur,	0·23		
Niccoliferous iron,	tr.		
	99.02		

The chromic oxyd corresponds to 0·62 per cent chromite, and the sulphur to 0·63 troilite.

From this composition it would appear that the mass is probably made up of uni- and bi-silicates. In a preliminary qualitative-quantitative analysis I found that more lime was contained in the acid solution than in the portion undecomposed by acid, while with the magnesia the larger amount re-

mained in the insoluble residue. The silicate decomposed by acids containing lime is most probably either anorthite, labradorite or a lime-olivine. The large portion of magnesia and iron insoluble in acid indicates the presence of a pyroxenic mineral. Further investigation is needed to fully establish the specific character of the constituent minerals of this meteorite, although we are justified in concluding that it contains an olivine, a pyroxenic mineral and a feldspar, besides chromite, troilite and a very small amount of niccoliferous iron. I think by sacrificing a large portion of this stone that its constituent minerals could be mechanically separated from each other by careful selection with the aid of a magnifier, and their specific characters accurately determined by analysis. At present I do not feel at liberty to undertake this, but hope at some future time to return to the study of this problem.

In general physical characters this meteorite very much resembles the Petersburg, Tenn., meteoric stone anlayzed and described by Prof. J. Lawrence Smith.* It has the same lustrous coating, and the constituent minerals are very much the same in character. It seems to belong to the class of meteorites that Prof. G. Rose† calls *Howardite*, and which he describes as being granular mixtures of olivine, with a white silicate (*anorthite ?*) and a small amount of chromite and niccoliferous iron. This class, according to Rose, includes the stones from Loutalox, Bialystok, Mässing, Nobleborough and Mallygaum.

I take pleasure in expressing my thanks to Mr. Hooper for his generosity in placing the stone at my disposal for examination, and to Mr. Pybas for his great interest in furnishing the data connected with its fall.

Sheffield Laboratory of Yale College, May, 1869.

Art. XXVI.—*Contributions to Zoölogy from the Museum of Yale College.* No. III.—*Descriptions of some new American Phyllopod Crustacea ;*‡ by A. E. Verrill.

Artemia Leach.

This interesting genus is remarkable for its habit of living and flourishing best in very saline and alkaline waters, such as the natural salt lakes of Egypt, Utah, etc., and the artificial brines formed by the evaporation of sea-water by exposure to the heat of the sun, as in England, France, and the West Indies.

* This Journal, II, xxxi, 264.

† Beschreibung und Eintheilung der Meteoriten, p. 107.

‡ Abstract from a paper read before the American Association for the Advancement of Science, Salem, Mass., Aug., 1869.

The species first made known, *A. salina* Leach (*Cancer salinus* Linn.), was first described by Schlosser,* who found it in great profusion in the brines of Lymington, England. Linné indicates it also from the salt lakes of Siberia (perhaps a distinct species) and probably the same as that observed by Pallas† in great numbers in the Great Schimélée. More recently it has been described from the salterns of southern France, at Montpellier, etc.‡ The genus has been found also in the Lakes Goumphidich, Amaruh and Bédah in Egypt, which are reported to be both very saline and alkaline, their bottoms being "covered with a layer of crystals of carbonate of soda, sulphate of soda, and common salt," while the density of the water is stated at 1·255. The Egyptian species appears not to have been described as yet.§ In the Antilles *A. Guildingi* Thompson occurs.‖ *A. Mulhausenii* Edw. (Fischer sp.) is found in Lake Loak in the Crimea.¶ A few years ago Prof. Silliman presented to the museum of Yale College a number of specimens of a new species, *A. Monica* V., which he collected in Mono Lake, California, where it occurs in great abundance associated with the larvæ of *Ephydra*.** The water of this lake is very dense, and not only very saline, but also so alkaline that it is said to be used for removing grease from clothing. I have been unable, however, to find any reliable analysis of this water. It is said to contain, also, biborate of soda. Prof. Silliman informs me that the genus also occurs in Little Salt Lake. It occurs in great abundance in Great Salt Lake, Utah, as I am informed by Prof. D. C. Eaton, who ob-

* Observations périodiques sur la physique, l'histoire naturelle et les beaux-arts, par Gautier, 1756, (with figures). An extract from this is republished in Annals des Sciences nat., 2e ser., t. 13, p. 226, 1840, in an elaborate description of the anatomy, development, habits, etc., of *Artemia salina* by M. Joly, illustrated by two excellent plates of the female and young. M. Joly failed to observe the male among more than a thousand females, and therefore doubted whether the sexes were distinct, suggesting that the males very well described by Schlosser were only the young, although that author described them as clasping the females in the well known manner, but he did not observe the actual copulation.

See also an article by Thomas Rackett, in Trans. Linn. Soc. of London, vol. xi, p. 205, pl. 14, 1812, (figures very bad); Thompson, Zoölogical Researches, No. 5, p. 105 t 1 and 2; W. Baird, Nat Hist. of the British Entomostraca, p. 61, tab. ii, figs. 2–4, (figures very good, but the specimens probably not full-grown).

† Voyage en différentes provinces de l'empire de Russie, t. ii, p. 505, (t. Joly).

‡ M. Payen, Note sur des animaux qui colorent en rouge les marais salans, Ann. des Sci. nat., 2e ser., t. 6, 1836, p. 219 (contains experiments on the effects caused by altering composition and density of the water); also op. cit., t. 10, 1838, p. 315; Joly, op. cit., t. 13, p. 225, 1840 (see above); Milne Edwards, Crustacés, t. iii, p. 369, 1840.

§ Audouin, Ann. des Sci. nat., 2e ser., t. 6, 1836, p. 230.

‖ Thompson, Zoöl. Researches, fas. 7, pl. 1, figs. 11–12.

¶ Edwards, Crustacés, t. iii, p. 370, 1840.

** Verrill, Proceedings Boston Soc. Nat. Hist., vol. xi, p. 3, 1866, (the larvæ were wrongly referred to *Eristalis*); Packard, on Insects inhabiting salt-water, Proc. Essex Inst., vol. vi, p. 41, 1869.

tained specimens there during the present summer, but these have not yet come to hand. The water of Great Salt Lake has usually been described by travelers as destitute of all life, but according to Prof. Eaton it contains not only an abundance of *Artemiæ*, but also various other small animals, insect larvæ, etc. The density of the water is stated at 1·170°, but doubtless varies much according to the season.* It yields, according to Dr. Gale, over 22 per cent of solid matter,† while the Syracuse Saline, one of the richest natural brines in the United States, contains but 19·16 per cent.‡ A few weeks ago Mr. Oscar Harger discovered another new species, *A. gracilis* V., near New Haven under very peculiar circumstances. On the long wooden bridge across West river and the extensive salt marsh on the West Haven side, are placed large wooden tubs filled with water from various pools on the marsh, to be used in case of fire. By long exposure to the sun and air the water in these becomes concentrated and thus furnishes suitable stations for the rapid increase of *Artemiæ*. On examining the tubs the first of August I found eight of them partly filled with water, in six of which the *Artemiæ* were found in abundance, though more numerous in one than in any of the others. In one tub, in which the water had a decidedly milky appearance, they were so abundant that hundreds could be obtained in a few minutes. The water in some of the other tubs containing them was of a reddish or brownish hue, or about the color of weak tea. In two no Artemiæ could be seen, and in these the water appeared to have been more recently renewed. Search was made in the pools from which the water had been taken, but no *Artemiæ* were found, though doubtless from these places the progenitors of those inhabiting the tubs must have been taken. It is probable that in the pools they exist in very small numbers, being kept in check partly by various small fishes and other enemies and partly by the unfavorable character of the water, while in the tubs the density of the water is more favorable for their rapid increase, and unfavorable or fatal to their enemies.§ The water

* The density of the water of the Atlantic ocean is stated at 1·020; that of the Dead Sea 1·130 to 1·227.

† This solid matter, according to Dr. Gale, (this Journal, II, vol. xvii, p. 129), has the following composition:

Chlorid of sodium,	20·196
Sulphate of soda,	1·834
Chlorid of magnesium,	·252
Chlorid of calcium,	trace
	22·282

‡ For analyses of several of these brines, see Dana's System of Mineralogy, p. 113.

§ The density of the water in two of the tubs containing most *Artemiæ*, was 1·065, equivalent to a brine containing 9·07 per cent of salt. One of those tested was brownish, the other milky.

from the tubs, when examined with a high power of the microscope, was found to be filled with immense numbers of infusoria of various kinds, such as monads, vibrios, and bacteria, most of which were so small as to be distinguishable only as moving points with a $\frac{1}{5}$ inch objective.

In the salterns of France the *Artemiæ* are associated with immense numbers of a monad, usually bright red in color, which has been named *Monas Dunalii* by Joly, who attributes to it the red color which the brine assumes just before crystallization,* as well as the red color observed in the *Artemiæ*, which doubtless feed upon it, as well as upon various other living infusoria, and dead animal and vegetable matter of various kinds.† The *Monas Dunalii* appears in abundance in the water having the density most favorable for *Artemia*, but increases in far greater proportion in the still denser, nearly or quite saturated brine in which *Artemia* does not live. The observations of Payen and Joly show that the *A. salina* of France can exist in waters varying in density from 4° to 20° Baumé, but that they flourish best in those that have a density of 10° to 15°.‡ According to Rackett those of Lymington do not live in the water which is undergoing the first stage of concentration, but only in the pans of concentrated brine, containing about "a quarter of a pound of salt to the pint."

Our *A. gracilis* can exist without apparent inconvenience when the water in which they occur is diluted with an equal bulk of fresh water as well as when it is much concentrated by evaporation. The water in which they were found varies in density from 1·060 to 1·065.

The genus is characterized by having eleven pair of four-jointed branchial "feet" or fins along the sides of the body, the middle ones being longest. Each joint of the "feet" bears flat branchial appendages, ciliated by sharp setæ, as in the other genera of the family. The abdomen is slender, six-jointed, the last joint long, terminated by two small projecting appendages, each bearing six to ten plumose setæ. The first abdominal segment bears the external sexual organs of the male, and a short, dilated, ovigerous pouch in the female. In the male the head bears in front a pair of large, three-jointed hooks or clasping organs, each of which has on the inner side of its basal joint a

* Reserches sur la Coloration en rouge des Marais Salans Méditerranéens, par M. Joly, Annals des Sciences naturelles, 2e ser., t. 13, 1840, p. 266.

† According to M. Joly, op. cit. p. 262, a beetle, *Hydroporus salinus* Joly, also inhabits the salterns, where the water has a density of 6° or 7° Baumé, and preys upon the *Artemiæ*.

‡ 4° to 20° Baumé is equivalent to a density of about 1·02 to 1·16; 10° to 15° =1·075 to 1·117. A brine having a density of 1·020, which is nearly that of sea-water, contains about 2·766 per cent of salt; one of 1·160 contains 21·219 per cent; one of 1·075 about 10·279 per cent; 1·117 about 15·794 per cent.

small, rounded, appendage; a pair of slender antennæ just back of these, terminated by two or three minute setæ; a pair of pedunculated compound eyes, and a dark spot on the middle of the head, which is the remains of the single eye of the young. The mouth below is provided with a broad labrum, a pair of mandibles, two pairs of jaws, and a pair of lateral papillæ. In the female the head lacks the stout claspers, which are replaced by a pair of comparatively small, simple, horn-shaped organs.

Artemia gracilis Verrill, sp. nov.

Body slender, in the male about ·3 of an inch long, in the female ·4. Claspers of the male relatively long and powerful, first joint thickened, with a distinct angle at the articulation on the outside and a short, rounded, nearly semicircular process on the inside near the base, about its own diameter from the base; second joint broad, flattened, continuous with the third joint, strongly curved, outline nearly regularly convex on the outside, until near the middle it suddenly bends inward forming an obtuse angle, beyond which the outline is concave to the last articulation, where it becomes again convex, forming on the last joint a slight, rounded angle, the inner edge is nearly straight, or but slightly concave, to the last articulation, where there is a slight but distinct angle; last joint triangular, longer than broad, tapering to the acute, slightly excurved point. Antennæ slender, elongated, reaching beyond the first articulation of the claspers, terminal setæ minute. Abdomen slender, smooth, the terminal lobes small, longer than broad, broadly rounded at the end, slightly constricted at the base inside, each bearing usually 7 or 9 plumose setæ, the central ones much the longest. Ovigerous pouch of the female, when seen from below, flask-shaped, the neck extending backward and downward, short, thick, subcylindrical toward the end, the body of the "flask" short, thick, swollen laterally, broader than long, the sides terminating outwardly in a small, triangular, sharp tooth, sometimes showing a minute spine. This pouch is generally filled with numerous large, brownish eggs.

Color generally reddish, flesh-color, or light greenish, translucent, the males usually lighter, greenish white, the intestines generally showing through as a dark reddish or greenish median line; eyes very dark brown, or black; ovaries often whitish, along each side of the abdomen.

An adult male gives the following measurements:

Distance between eyes 1·81^{mm}; breadth of head ·76; length of eye-stalks ·62; length of first joint of the claspers ·91; its breadth ·72; breadth of its appendage ·18; length of second

and third joints from outer edge of first articulation to the tip 2·48; greatest breadth ·86; breadth at last articulation ·72; length of last joint 1·05; length of last joint of abdomen, exclusive of appendages, 1·00; its breadth ·31; length of preceding joint ·42; its breadth ·37; length of terminal appendages ·21; breadth ·096; length of longest setæ ·70.

Near New Haven, in tubs of water from salt marsh.

Artemia Monica Verrill, sp. nov.

Form similar to that of the preceding species, but a little larger and stouter. The largest female is 13^{mm} (·52 of an inch) long, the abdomen being 6^{mm}; and 5^{mm} across the branchial feet in their natural, partly extended position. The largest male is 11·5^{mm} (·45 of an inch) long, the abdomen being 6^{mm}. The claspers of the male are relatively stouter, the hook or outer two joints being much broader, more triangular, and less elongated. The inner edge of the first joint, as seen from below, is regularly convex, bearing the appendage on its most convex part and not so near the base as in *A. gracilis*, the distance being about twice the breadth of the organ, which is about as broad as long and regularly rounded. At the articulation the outer edge of the joint projects as a distinct angle. The second and third joint together have a nearly triangular form, the breadth being about half the length; the outer edge is regularly rounded, shorter than in the preceding; it forms little more than a right angle with the front edge, which is nearly straight or a little concave, sometimes slightly convex at the last articulation, but not forming a distinct angle there; the inner edge of the hook is a little concave on the first joint, becoming convex at the last articulation where there is a distinct but very obtuse angle. The last joint is almost regularly triangular, about as broad as long, tapering to an obtuse point, the inner edge being a little convex. The antennæ are very slender and do not reach the first articulation of the claspers. The caudal appendages are smaller than in *A. gracilis*, and scarcely longer than broad, rounded at the end, terminated by nine or ten very slender plumose setæ. The egg-pouch of the female is broad flask-shaped, strongly convex in the middle below, the sides not forming such sharp angles as in *A. gracilis*.

The English specimens of *A. salina*, as figured by Baird, differ from both the preceding species in having longer, more curved, and sharper clasping hooks, and the basal appendage more elongated; the egg-pouch, though badly figured, is of a very different form. The French specimens, as figured by Joly, appear like a distinct species, the egg-pouch being of a very different form, and the caudal appendages very much longer and

larger than in either of our species, while Baird's figure represents them as very small; but his specimens appear to have been smaller, and may have been immature, for these species begin to breed before they are half grown. Whether the French species be distinct from the English can only be determined by additional examinations, especially of the male, for the male of the former appears not to have been figured hitherto.

BRANCHIPUS Shœffer.

Branchipus Shœffer, Elementa entomologica, 1766, (type, *B. pisciformis*=(?) *B. stagnalis* Linn. sp.).

Branchipus (*pars*) Lamarck; Latreille; Leach; Edwards.

Chirocephalus (*pars*) Dana, (non Bénédict-Prévost, 1803; Jurine; Thompson; Baird).

Under the name of *Branchipus* at least four generic groups have been confounded by various authors.

Branchipus should be restricted to the original species described by Shœffer and the allied species, of which *B. stagnalis* (Linn. sp.) is one, and if not identical with *B. pisciformis*, as is generally supposed, must be closely allied.

As thus restricted the genus is characterized by the stout, two-jointed claspers of the male, with or without a tooth near the base of the hook, the basal joint being swollen; by having a pair of simple appendages resembling antennæ between the bases of the claspers in front; by the large, thick, oval egg-pouches of the female, and, apparently, by the structure of the branchial organs. It includes *B. stagnalis*, *B. spinosus* Edw., *B. vernalis* Verrill, sp. nov., etc. Perhaps *B. paludosus* Müller also belongs here.

Branchinecta.—A group of species allied to these,—but destitute of all appendages between the bases of the claspers of the male, which are more slender and simple; with a much elongated egg-pouch, having lateral lobes at the base; a more slender body, with more elongated branchial organs, the middle ones longest; and having, in general appearance, a much stronger resemblance to *Artemia*,—probably constitutes another genus, but for the present we prefer to regard it as a subgenus of *Branchipus*.

For this group we propose the name *Branchinecta*. It includes two new arctic species, *B. Grœnlandica* and *B. arctica*, and *B. ferox* (Edw. sp.) from near Odessa.

Heterobranchipus.—Dr. Loven* has described a singular species, *B. Cafer*, which appears worthy to constitute a distinct genus. It is remarkable on account of the very curious claspers of the male, which are very long, three-jointed, flexuous, the

* Kongl. Vet. Akad. Handl, 1846, p. 433, tab. V.

basal joint bearing a long cirrus externally and a lacerate tooth on the inner side of the base, the outer joint bifid, the internal part cirriform, the external one deeply bilobed. External male organs very long, slender, curved, outer portion serrate on the outer edge, with short setæ on the inner edge; egg-pouches long, slender, slightly enlarged and beaked at the end; branchiæ of a peculiar structure; front of head, between the claspers, with a short bimucronate rostrum.

H. Cafer is from the marshes of Natal, South Africa.

Chirocephalus Prevost, 1803.—This genus, established for *C. diaphanus*, is evidently very distinct from all the preceding. The typical species is large, stout, and remarkable for the singular appendages between the claspers of the male, on the front of the head. These consist of two long, ligulate, fleshy processes, serrated on each side, which coil in a spiral beneath the head, but when extended, as in copulation, reaching beyond the claspers; attached to the outer side of each of these are four long processes, strongly serrate on the inner edge, and near the base another large, broad, thin, subtriangular appendage, its edges strongly serrate, especially in front, capable of folding up like a fan when not in use. The claspers have a much swollen basal joint, a strongly serrate tooth on the inside of the base of the second joint, which is beyond this slender and regularly curved. Egg-pouch long-oval, large and thick; caudal appendages large; male organs and branchiæ peculiar.

C. diaphanus Prev., inhabits fresh water pools in France, Switzerland, and England. It is well described and figured in Baird's British Entomostraca, p. 39, tab. III and IV.

Branchipus vernalis Verrill, sp. nov.

Form rather stout, large; the full grown females are 23^{mm} (·90 of an inch) long, the abdomen being 14^{mm}; and 6·5^{mm} wide across the branchial organs in their natural position; breadth of head across the eyes 4^{mm}. A large male is 22^{mm} (·86 of an inch) long, the body 12^{mm}; the breadth of head across eyes 5^{mm}; the entire length of claspers 8^{mm}. The claspers are very large and strong, the basal joint much swollen with a soft integument, capable of retracting the basal portion of the second joint into itself by involution of its outer edge; the second joint is elongated, broad and stout at base, with an angle on the outside, from which it rapidly narrows by strongly concave outlines on each edge, but most so on the outside; at the constricted portion, not far from the base, it bears a large, strong, very prominent, crooked, bluntly pointed tooth, which is directed inward and backward, not serrate on its outer side; beyond the tooth the rest of the joint is long and

rather slender, curved outward and forward at base, having just beyond the tooth on the inside a distinct but very obtuse rounded angle, from which the outline slightly curves inward to near the tip, which is a little dilated and recurved. The basal portion, including the tooth, is retracted into the first joint in some specimens. On the front of the head between the basal joints of the claspers are two flat, short, lanceolate, ligulate, fleshy processes, with finely serrate edges, usually coiled down, but when extended scarcely more than half as long as the basal joint of the claspers. Antennæ small and very slender, tapering, reaching a little beyond the eyes. Caudal appendages long, rather narrow, slightly swollen at base, gradually tapering to the acute tips, and bearing along the sides, except at base, very numerous, long plumose setæ. Egg-pouches short, broad-oval, nearly as wide as long, slightly three-lobed posteriorly, the central lobe largest, sides extended and largely adherent to the sides of the abdomen, length 4^{mm}, width 3·5. Body flesh color or pale red, the intestine darker red or greenish.

A large male gives the following measurements: length of first joint of claspers 4·62^{mm}; diameter 2·40; length of second joint 4·14; breadth at base 1·90; at tooth ·72; in middle ·52; length of tooth ·90; its diameter ·33; length of caudal appendages 4; breadth at base ·33; in middle ·20; length of setæ 2; length of antennæ 3.

New Haven, in stagnant pools,—J. D. Dana, D. C. Eaton, A. E. Verrill; Salem, Mass., April 19, 1859, R. H. Wheatland, C. Cooke (from Essex Institute); Cambridge, Mass., A. E. Verrill.

This species differs widely from all described species of Europe, in the character of the claspers of the male and their appendages. *B. stagnalis* has a pair of long setiform organs between the claspers, and a tooth on the outer side of their second joint; *B. spinosus* resembles our species somewhat in the frontal appendages between the claspers, but lacks the conspicuous tooth at the base of their second joint. The shape of the egg-pouch in our species is also characteristic.

This is doubtless the species referred to by Dr. Gould under the name of *Branchipus stagnalis*.* Dekay† copies the diagnosis of *B. stagnalis* (*?*) from a foreign work, and gives a figure of *Chirocephalus diaphanus*, copied apparently from Desmarets, pl. 56, which is itself a copy.

* Invertebrata of Massachusetts, p. 339.

† Natural History of New York, Zoölogy, Part I, Crustacea, p. 63, pl. IX, fig. 36.

This species appears very early in spring, often in great numbers, in quiet pools. I have never seen it later than the middle of May, yet since the individuals seen in early spring are full-grown, it might, doubtless, be found also in autumn.

Branchipus (*Branchinecta*) *arcticus* Verrill, sp. nov.

Branchipus paludosus Packard, Invertebrate Fauna of Labrador, in Mem. Boston Soc. Natural History, i, p. 295, (*non* Müller).

Form slender, body short, abdomen elongated. A full sized male is 20^{mm} (·80 of an inch) long, exclusive of the claspers, the abdomen being 13^{mm}; the breadth between the eyes 3^{mm}. A female 20^{mm} long, with the abdomen 12^{mm}, has an egg-pouch 6·2 long. Branchial "feet" slender, elongated, the middle ones longest, 4 to 5^{mm} long when extended. Claspers of the male rather long and slender; the basal joint is but little swollen, elongated, regularly curved, with a small tooth or prominent angle at the articulation on the inside, and on the inner side a row of numerous small, distinct, sharp teeth, extending from the articulation about half way to the base, and arranged somewhat obliquely; second joint slender, regularly curved, tapering to a blunt point, the inner edge minutely serrulate. Front simply curved, with no appendages. Antennæ slender, scarcely more than half the length of the basal joint of the claspers. Labrum long and narrow, mandibles stout, strongly curved, bluntly pointed. Caudal appendages slender lanceolate, rather small, with long slender setæ. Egg-pouch much elongated, slender, subcylindrical, beaked or slightly bilobed at the end, the upper or dorsal lobe longest, its basal portion with two small rounded lateral lobes.

A large male gives the following measurements: breadth between outer extremity of eyes 3·46^{mm}; diameter of eyes ·66; length of basal joint of claspers 1·66; breadth ·71; length of second joint 1·29; breadth at its base ·46; width of mandibles at middle ·66; length of caudal appendages ·96; breadth at base ·16; length of longest setæ ·84 to 1^{mm}.

Color of preserved specimens pale reddish, with dark green intestine. Labrador, at "Indian Tickle" on the north shore of Invuctoke Inlet, abundant in a pool of fresh water,—Dr. A. S. Packard.

Branchipus (*Branchinecta*) *Grœnlandicus* Verrill, sp. nov.

A little stouter than the last; the largest male is 17^{mm} long exclusive of claspers, the abdomen being 10^{mm}, including caudal appendages. Claspers similar to those of *B. arcticus* but more elongated, the basal joint less curved, and the second joint longer, less regularly curved, tapering more quickly at base and consequently more attenuated beyond the middle and with more slender tips, which are nearly straight. The tooth on the in-

side of the first joint is rather more prominent, but the row of teeth along the inside is similar. Caudal appendages stouter, tapering more rapidly. External male organs slender, curved outward, swollen at base. The largest female is not mature and the egg-pouch contains no eggs; it is small, slender, elongated, subcylindrical, beaked at the end.

The largest male gives the following measurements: breadth between eyes 3·20^{mm}; length of basal joint of claspers 2·81; breadth ·95; length of second joint 2·24; its breadth at base ·76; length of caudal appendages ·86; width at base ·24; length of setæ ·76.

Greenland,—Dr. Chr. Lutken, (from the University Zoölogical Museum, Copenhagen.)

Of this species I have seen but four specimens, which were sent to Dr. A. S. Packard by Dr. Lutken under the name of *B. paludosus* Müller. The latter appears to be quite distinct, to judge from the figures; it is represented as having appendages between the claspers, and very slender, linear, caudal appendages. In the form of the egg-pouch, and the serration of the first joint of the claspers it is similar.

This species is very closely allied to *B. arcticus*, and when a larger series of specimens can be examined it may prove to be only a local variety, but the specimens studied show differences that seems to warrant their separation.

ART. XXVII.—*On the Lesleyite of Chester Co., Penn., and its relations to the Ephesite of the Emery formation near Ephesus, Asia Minor;* by J. LAWRENCE SMITH.

SEVERAL years ago a small amount of mineral from Chester Co., Penn., was handed to me for examination by Dr. Isaac Lea of Philadelphia. The specimen was too impure to warrant any conclusion upon analysis. Its character and associates, however, led me to suppose that it was the same mineral described by me as associated with the emery of Asia Minor and to which I gave the name *Ephesite*. In the mean time Dr. Lea described his mineral as a new species, calling it *Lesleyite;* and in a recent number of the American Journal of Science, S. P. Sharples has given an analysis of it, that at once brought to my recollection my original opinion that it was close to *Ephesite*, and on recurring to my examination of this mineral, making due allowance of the impurities contained in it, the opinion was confirmed.

I then obtained from Dr. Lea another specimen of his mineral and proceeded to analyze both it and the Ephesite for mutual comparison. Much labor was bestowed in selecting the pure

mineral from each, the greater part of a day having been consumed in procuring the necessary quantity for analysis. They are similar in their associations and identical in color and luster, and general physical properties. They are both very difficult to decompose by carbonate of soda, even when aided with caustic potash; so that in both analyses the silica obtained was fused a second time and much alumina separated from it.

My original description of the mineral will be found under Emery, in this Journal, II, vol. x, 1850, as follows:

"It is of a pearly white color, and lamellar in structure; cleavage difficult. It scratches glass easily, and has a sp. gr. of from 3·15 to 3·20. Heated before the blowpipe it becomes milk-white but does not fuse. At first sight it might be taken for white disthene. It is decomposed with great difficulty by carbonate of soda even with the addition of a little caustic soda."

The Lesleyite has identically the same properties. On analysis the two minerals were found to be composed as follows:

	Ephesite.	Lesleyite.
Silica	30·70	31·18
Alumina	55·67	55·00
Lime	2·55	0·45
Soda	5·52	1·20
Potash	1·10	7·28
Water	4·91	4·80
	100·45	99·91

The alkalies in the two varieties are reversed, the Ephesite containing principally soda, and the Lesleyite potash.

This close relation of the two minerals is an interesting fact as regards the associate minerals of corundum found in different parts of the world.

In regard to the reddish variety of Lesleyite examined by Roepper, the analysis cannot be considered as giving very satisfactory results, for the mineral may have been impure, and the difficulty in decomposing by the soda fusion may give very erroneous results in a silica determination.

Louisville, Ky., August, 1869.

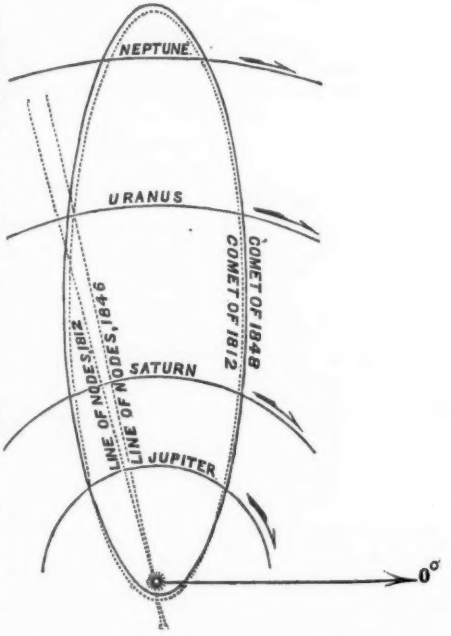
Art. XXVIII.—*On the Origin of the Comets of* 1812 *and* 1846 IV; by Prof. Daniel Kirkwood.

The comet of 1812 was discovered by Pons on the 20th of July, and continued to be observed till about the last of September. It became visible to the naked eye shortly after its discovery, its tail attaining a length of more than 2°.

The fourth comet of 1846 was discovered by DeVico, at the Collegio Romano, on the 20th of February, and continued visible about 10 weeks. The elements of these comets are as follows:

Perihelion Passage.	Long. of Per.	Long. of Asc. Node.	Incl.	Perih. Dist.	Eccentricity.	Period.	Direction.	Computor.
						y.		
1812, Sept. 15d, 7h.	92° 51′	253° 33′	73° 57′	0·7771	0·95454	70·68	D	Encke.
1846, Mar. 5, 12,	90° 31′	77° 37′	85° 6′	0·6637	0·96224	73·715	D	Peirce.

The wonderful similarity of these elements, except in the longitude of the ascending node, is at once apparent. It will also be noticed that the longitude of the *descending* node of the latter is very nearly coincident with that of the *ascending* node of the former. These remarkable coincidences are presented to the eye in the following diagram, where the dotted ellipse represents the orbit of the comet of 1812, and the continuous curve, that of the comet of 1846.



It is infinitely improbable that these coincidences should be accidental: they point, undoubtedly to a common origin of the two bodies.

The theory of comets now generally accepted is that they enter the solar system *ab extra*, move in parabolas or hyperbolas around the sun, and, if undisturbed by the planets, pass off beyond the limits of our system to be seen no more. If in their motion, however, they approach very near any of the larger planets, their direction is changed by planetary perturbations; their orbits being sometimes transformed into ellipses. The new orbits of such bodies would pass very nearly through the points at which their greatest perturbation occurred: and

accordingly we find that the aphelia of a large proportion of the periodic comets are near the orbits of the major planets. "I admit," says M. Hoek, "that the orbits of comets are by nature parabolas or hyperbolas, and that in the cases when elliptical orbits are met with, these are occasioned by planetary attractions, or derive their character from the uncertainty of our observations. To allow the contrary would be to admit some comets as permanent members of our planetary system, to which they ought to have belonged since its origin, and so to assert the simultaneous birth of that system and of these comets. As for me I attribute to these a primitive wandering character. Traveling through space they move from one star to another in order to leave it again, provided they do not meet any obstacle that may force them to remain in its vicinity. Such an obstacle was *Jupiter*, in the neighborhood of our sun, for the comets of Lexell and Brorsen, and probably for the greater part of periodical comets; the other part of which may be indebted for their elliptical orbits to the attractions of *Saturn* and the remaining planets.

"Generally then, comets come to us from some star or other. The attraction of our sun modifies their orbit, as had been done already by each star through whose sphere of attraction they had passed. We can put the question if they come as single bodies or united in systems. This is the point I have undertaken to investigate. Since some time already I had felt the truth of the following thesis:—

"*There are systems of comets in space that are broken up by the attraction of our sun, and whose members attain, as isolated bodies, the vicinity of the Earth during a course of several years.*"*

In the researches here referred to it has been shown by M. Hoek that the comets of 1860, III, 1863, I, and 1863, VI, formed a group in space previous to their entrance into our system. The same fact has also been demonstrated in regard to other comets which need not here be specified. Now, the comets of 1812 and 1846 IV. have their aphelions very near the orbit of Neptune, and hence the original parabolas in which they moved were probably transformed into ellipses by the perturbations of that planet. Before entering the solar domain they were doubtless members of a cometary system. Passing Neptune near the same time, and at some distance from each other, their different relative positions with regard to the disturbing body may account for the slight differences in the elements of their orbits.

At what epoch did they enter the solar system?—The mean between the longitudes of the aphelia of the two comets is

* Monthly Notices, vol. xxv, p. 243.

271° 41′. Neptune had this longitude in 1775; the comet of 1812, in 1777; and that of 1846, in 1809. Now, with the known period of Neptune and the periods of the comets as determined by Encke and Peirce, we find (neglecting perturbations) that—

Neptune was in longitude 271° 41′ in the year 694 B. C.;
the comet of 1812, " " " 696 "
" 1846, IV. " " " 696 "

It seems, therefore, that the three bodies were very nearly together about 695 years before the Christian era. It is consequently not improbable that the elliptical form of the two comentary orbits dates from this epoch.

Bloomington, Indiana, June 17th, 1869.

SCIENTIFIC INTELLIGENCE.

I. PHYSICS.

1. *On the Blue Color of the Sky, the Polarization of Skylight, and on the Polarization of Light by Cloudy matter generally;* by JOHN TYNDALL, LL.D., F.R.S.—Since the communication of my brief abstract "On a new Series of Chemical Reactions produced by Light," the experiments upon this subject have been continued, and the number of the substances thus acted on considerably augmented. New relations have also been established between *mixed vapors* when subjected to the action of light.

I now beg to draw the attention of the Royal Society to two questions glanced at incidentally in the abstract referred to,—the blue color of the sky, and the polarization of skylight. Reserving the historic treatment of the subject for a more fitting occasion, I would merely mention now that these questions constitute, in the opinion of our most eminent authorities, the two great standing enigmas of meteorology. Indeed it was the interest manifested in them by Sir John Herschel, in a letter of singular speculative power, that caused me to enter upon the consideration of these questions so soon.

The apparatus with which I work consists, as already stated to the Society, of a glass tube about a yard in length, and from 2½ to 3 inches internal diameter. The vapor to be examined is introduced into this tube in the manner described in my last abstract, and upon it the condensed beam of the electric lamp is permitted to act until the neutrality or the activity of the substance has been declared.

It has hitherto been my aim to render the chemical action of light upon vapors *visible*. For this purpose substances have been chosen, *one* at least of whose products of decomposition under light shall have a boiling-point so high that as soon as the substance is formed it shall be *precipitated*. By graduating the quantity of the vapor, this precipitation may be rendered of any de-

gree of fineness, forming particles distinguishable by the naked eye, or particles which are probably far beyond the reach of our highest microscopic powers.

I have no reason to doubt that particles may be thus obtained whose diameters constitute but a very small fraction of the length of a wave of violet light.

In all cases when the vapors of the liquids employed are sufficiently attenuated, no matter what the liquid may be, the visible action commences with the formation of a *blue cloud.* I would guard myself at the outset against all misconception as to the use of this term. The blue cloud to which I here refer is totally invisible in ordinary daylight. To be seen, it requires to be surrounded by darkness, *it only* being illuminated by a powerful beam of light. This blue cloud differs in many important particulars from the finest ordinary clouds, and might justly have assigned to it an intermediate position between these clouds and true cloudless vapor.

With this explanation, the term "cloud," or "incipient cloud," as I propose to employ it, cannot, I think, be misunderstood.

I had been endeavoring to decompose carbonic acid gas by light. A faint bluish cloud, due it may be, or it may not be, to the residue of some vapor previously employed, was formed in the experimental tube. On looking across this cloud through a Nicol's prism, the line of vision being horizontal, it was found that when the short diagonal of the prism was vertical, the quantity of light reaching the eye was greater than when the long diagonal was vertical.

When a plate of tourmaline was held between the eye and the bluish cloud, the quantity of light reaching the eye when the axis of the prism was perpendicular to the axis of the illuminating beam, was greater than when the axes of the crystal and of the beam were parallel to each other.

This was the result all round the experimental tube. Causing the crystal of tourmaline to revolve round the tube, with its axis perpendicular to the illuminating beam, the quantity of light that reached the eye was in all its positions a maximum. When the crystallographic axis was parallel to the axis of the beam, the quantity of light transmitted by the crystal was a minimum.

From the illuminated bluish cloud, therefore, polarized light was discharged, the direction of maximum polarization being at right angles to the illuminating beam; the *plane of vibration* of the polarized light, moreover, was that to which the beam was perpendicular.*

Thin plates of selenite or of quartz, placed between the Nicol and the bluish cloud, displayed the colors of polarized light, these colors being most vivid when the line of vision was at right angles to the experimental tube. The plate of selenite usually employed

* I assume here that the plane of vibration is perpendicular to the plane of polarization. This is still an undecided point; but the probabilities are so much in its favor, and it is in my opinion so much preferable to have a physical image on which the mind can rest, that I do not hesitate to employ the phraseology in the text. Even should the assumption prove to be incorrect, no harm will be done by the provisional use of it.

was a circle, thinnest at the center, and augmenting uniformly in thickness from the center outward. When placed in its proper position between the Nicol and the cloud, it exhibited a system of splendidly colored rings.

The cloud here referred to was the first operated upon in the manner described. It may, however, be greatly improved upon by the choice of proper substances, and by the application in proper quantities of the substances chosen. Benzol, bisulphid of carbon, nitrite of amyl, nitrite of butyl, iodid of allyl, iodid of isopropyl, and many other substances may be employed. I will take the nitrite of butyl as illustrative of the means adopted to secure the best result with reference to the present question.

And here it may be mentioned that a vapor, which when alone, or mixed with air in the experimental tube, resists the action of light, or shows but a feeble result of this action, may, by placing it in proximity with another gas or vapor, be caused to exhibit under light vigorous, if not violent action. The case is similar to that of carbonic acid gas, which diffused in the atmosphere resists the decomposing action of solar light, but when placed in contiguity with the chlorophyl in the leaves of plants, has its molecules shaken asunder.

Dry air was permitted to bubble through the liquid nitrite of butyl until the experimental tube, which had been previously exhausted, was filled with the mixed air and vapor. The visible action of light upon the mixture after fifteen minutes' exposure was slight. The tube was afterwards filled with half an atmosphere of the mixed air and vapor, and another half atmosphere of air which had been permitted to bubble through fresh commercial hydrochloric acid. On sending the beam through this mixture, the action paused barely sufficiently long to show that at the moment of commencement the tube was optically empty. But the pause amounted only to a small fraction of a second, a dense cloud being immediately precipitated upon the beam which traversed the mixture.

This cloud began *blue*, but the advance to whiteness was so rapid as almost to justify the application of the term instantaneous. The dense cloud, looked at perpendicularly to its axis, showed scarcely any signs of polarization. Looked at obliquely the polarization was strong.

The experimental tube being again cleansed and exhausted, the mixed air and nitrite-of-butyl vapor was permitted to enter it until the associated mercury column was depressed $\frac{1}{10}$ of an inch. In other words, the air and vapor, united, exercised a pressure not exceeding $\frac{1}{300}$ of an atmosphere. Air passed through a solution of hydrochloric acid was then added till the mercury column was depressed three inches. The condensed beam of the electric light passed for some time in darkness through this mixture. There was absolutely nothing within the tube competent to scatter the light. Soon, however, a superbly blue cloud was formed along the track of the beam, and it continued blue sufficiently long to permit of its thorough examination. The light discharged from the cloud at

right angles to its own length was *perfectly* polarized. By degrees the cloud became of whitish blue, and for a time the selenite colors obtained by looking at it normally were exceedingly brilliant. The direction of maximum polarization was distinctly at right angles to the illuminating beam. This continued to be the case as long as the cloud maintained a decided blue color, and even for some time after the pure blue had changed to whitish blue. But as the light continued to act the cloud became coarser and whiter, particularly at its center, where it at length ceased to discharge polarized light in the direction of the perpendicular, while it continued to do so at both its ends.

But the cloud which had thus ceased to polarize the light emitted normally, showed vivid selenite colors when looked at *obliquely*. The direction of maximum polarization changed with the texture of the cloud. This point shall receive further illustration subsequently.

A blue, equally rich and more durable, was obtained by employing the nitrite-of-butyl vapor in a still more attenuated condition. Now the instance here cited is *representative*. In all cases, and with all substances, the cloud formed at the commencement, when the precipitated particles are sufficiently fine, is *blue*, and it can be made to display a color rivaling that of the purest Italian sky. In all cases, moreover, this fine blue cloud polarizes *perfectly* the beam which illuminates it, the direction of polarization enclosing an angle of 90° with the axis of the illuminating beam.

It is exceedingly interesting to observe both the perfection and the decay of this polarization. For ten or fifteen minutes after its first appearance the light from a vividly illuminated incipient cloud, looked at horizontally, is absolutely quenched by a Nicol's prism with its longer diagonal vertical. But as the sky-blue is gradually rendered impure by the introduction of particles of too large a size, in other words, as real clouds begin to be formed, the polarization begins to deteriorate, a portion of the light passing through the prism in all its positions. It is worthy of note that for some time after the cessation of perfect polarization the *residual* light which passes, when the Nicol is in its position of minimum transmission, is of a gorgeous blue, the whiter light of the cloud being extinguished.* When the cloud texture has become sufficiently coarse to approximate to that of ordinary clouds, the rotation of the Nicol ceases to have any sensible effect on the quality of the light discharged normally.

The perfection of the polarization in a direction perpendicular to the illuminating beam is also illustrated by the following experiment. A Nicol's prism large enough to embrace the entire beam of the electric lamp was placed between the lamp and the experimental tube. A few bubbles of air carried through the liquid nitrite of butyl were introduced into the tube, and they were followed by about 3 inches (measured by the mercurial gauge) of air

* This seems to prove that particles too large to polarize the blue, polarize perfectly light of lower refrangibility.

which had been passed through aqueous hydrochloric acid. Sending the polarized beam through the tube, I placed myself in front of it, my eye being on a level with its axis, my assistant, Mr. Cottrell, occupying a similar position behind the tube. The short diagonal of the large Nicol was in the first instance vertical, the plane of vibration of the emergent beam being therefore also vertical. As the light continued to act, a superb blue cloud visible to both my assistant and myself was slowly formed. But this cloud, so deep and rich when looked at from the positions mentioned, *utterly disappeared when looked at vertically downward, or vertically upward.* Reflection from the cloud was not possible in these directions. When the large Nicol was slowly turned round its axis, the eye of the observer being on the level of the beam, and the line of vision perpendicular to it, entire extinction of the light emitted horizontally occurred where the longer diagonal of the large Nicol was vertical. But now a vivid blue cloud was seen when looked at downward or upward. This truly fine experiment was first definitely suggested by a remark addressed to me in a letter by Prof. Stokes.

Now, as regards the polarization of skylight, the greatest stumbling block has hitherto been that, in accordance with the law of Brewster, which makes the index of refraction the tangent of the polarizing angle, the reflection which produces perfect polarization would require to be made *in* air *upon* air; and indeed this led many of our most eminent men, Brewster himself among the number, to entertain the idea of *molecular reflection.* I have, however, operated upon substances of widely different refractive indices, and therefore of very different polarizing angles as ordinarily defined, but the polarization of the beam by the incipient cloud has thus far proved itself to be *absolutely independent of the polarizing angle.* The law of Brewster does not apply to matter in this condition, and it rests with the undulatory theory to explain why. Whenever the precipitated particles are sufficiently fine, no matter what the substance forming the particles may be, the direction of maximum polarization is at right angles to the illuminating beam, the polarizing angle for matter in this condition being invariably 45°. This I consider to be a point of capital importance with reference to the present question.*

That *water-particles*, if they could be obtained in this exceedingly fine state of division, would produce the same effects, does not admit of reasonable doubt. And that they must exist in this con-

* The difficulty referred to above is thus expressed by Sir John Herschel:—"The cause of the polarization is evidently a reflection of the sun's light upon *something*. The question is on what? Were the angle of maximum polarization 76°, we should look to water or ice as the reflecting body, however inconceivable the existence in a cloudless atmosphere, and a hot summer's day of unevaporated molecules (particles?) of water. But though we were once of this opinion, careful observation has satisfied us that 90°, or thereabouts, is a correct angle, and that therefore whatever be the body on which the light has been reflected *if polarized by a single reflection*, the polarizing angle must be 45°, and the index of refraction, which is the tangent of that angle, unity; in other words, the reflection would require to be made *in* air *upon* air!" ('Meteorology,' par. 233).

dition in the higher regions of the atmosphere is, I think, certain. At all events, no other assumption than this is necessary to completely account for the firmamental blue and the polarization of the sky.*

Suppose our atmosphere surrounded by an envelope impervious to light, but with an aperture on the sunward side through which a parallel beam of solar light could enter and traverse the atmosphere. Surrounded on all sides by air not directly illuminated, the track of such a beam through the air would resemble that of the parallel beam of the electric lamp through an incipient cloud. The sunbeam would be *blue*, and it would discharge laterally light in precisely the same condition as that discharged by the incipient cloud. In fact the azure revealed by such a beam would be to all intents and purposes that which I have called a "blue cloud."†

But, as regards the polarization of the sky, we know that not only is the direction of maximum polarization at right angles to the track of the solar beams, but that at certain angular distances, probably variable ones, from the sun, "neutral points," or points of no polarization, exist, on both sides of which the planes of atmospheric polarization are at right angles to each other.

I have made various observations upon this subject which I reserve for the present; but pending the more complete examination of the question, the following facts and observations bearing upon it are submitted to the Royal Society.

The parallel beam employed in these experiments tracked its way through the laboratory air exactly as sun-beams are seen to do in the dusty air of London. I have reason to believe that a great portion of the matter thus floating in the laboratory air consists of organic germs, which are capable of imparting a perceptibly bluish tint to the air. This air showed, though far less vividly, all the effects of polarization obtained with the incipient clouds. The light discharged laterally from the track of the illuminating beam was polarized, though not perfectly, the direction of maximum polarization being at right angles to the beam.

The horizontal column of air thus illuminated was 18 feet long, and could therefore be looked at very obliquely without any disturbance from a solid envelope. At all points of the beam through-

* Any particles, if small enough, will produce both the color and the polarization of the sky. But is the existence of small water-particles on a hot summer's day *in the higher regions of our atmosphere* inconceivable? It is to be remembered that the oxygen and nitrogen of the air behave as a vacuum to radiant heat, the exceedingly attenuated vapor of the higher atmosphere being therefore in practical contact with the cold of space.

† The opinion of Sir John Herschel, connecting the polarization and the blue color of the sky is verified by the foregoing results "The more the subject [the polarization of skylight] is considered," writes this eminent philosopher, "the more it will be found beset with difficulties, and its explanation when arrived at will probably be found to carry with it that of the blue color of the sky itself and of the great quantity of light it actually does send down to us." "We may observe, too," he adds, "that it is only where the purity of the sky is most absolute that the polarization is developed in its highest degree, and that where there is the slightest perceptible tendency to cirrus it is materially impaired." This applies word for word to the "incipient clouds."

out its entire length the light emitted normally was in the same state of polarization. Keeping the positions of the Nicol and the selenite constant, the same colors were observed throughout the entire beam when the line of vision was perpendicular to its length.

I then placed myself near the end of the beam as it issued from the electric lamp, and looking through the Nicol and selenite more and more obliquely at the beam, observed the colors fading until they disappeared. Augmenting the obliquity the colors appeared once more, *but they were now complementary to the former ones.*

Hence this beam, like the sky, exhibited its neutral point, at opposite sides of which the light was polarized in planes at right angles to each other.

Thinking that the action observed in the laboratory might be caused in some way by the vaporous fumes diffused in its air, I had a battery and an electric lamp carried to a room at the top of the Royal Institution. The track of the beam was seen very finely in the air of this room, a length of 14 or 15 feet being attainable. This beam exhibited all the effects observed with the beam in the laboratory. Even the uncondensed electric light falling on the floating matter showed, though faintly, the effects of polarization.*

When the air was so sifted as to entirely remove the visible floating matter, it no longer exerted any sensible action upon the light, but behaved like a vacuum.

I had varied and confirmed in many ways those experiments on neutral points, operating upon the fumes of chlorid of ammonium, the smoke of brown paper, and tobacco smoke, when my attention was drawn by Sir Charles Wheatstone to an important observation communicated to the Paris Academy in 1860, by Professor Govi, of Turin.† His observations on the light of comets had led M. Govi to examine a beam of light sent through a room in which was diffused the smoke of incense. He also operated on tobacco smoke. His first brief communication stated the fact of polarization by such smoke, but in his second communication he announced the discovery of a neutral point in the beam, at the opposite sides of which the light was polarized in planes at right angles to each other.

But unlike my observations on the laboratory air, and unlike the action of the sky, the direction of maximum polarization in M. Govi's experiment enclosed a very small angle with the axis of the illuminating beam. The question was left in this condition, and I am not aware that M. Govi or any other investigator has pursued it further.

I had noticed, as before stated, that as the clouds formed in the experimental tube became denser, the polarization of the light discharged at right angles to the beam became weaker, the direction of maximum polarization becoming oblique to the beam. Experiments on the fumes of chlorid of ammonium gave me also reason

* I hope to try Alpine air next summer.

† Comptes Rendus, tome li, pp. 360 and 669.

to suspect that the position of the neutral point *was not constant*, but that it varied with the density of the illuminated fumes.

The examination of these questions led to the following new and remarkable results:—the laboratory being well filled with the fumes of incense, and sufficient time being allowed for their uniform diffusion, the electric beam was sent through the smoke. From the track of the beam polarized light was discharged, but the direction of maximum polarization, instead of being along the normal, now enclosed an angle of 12° or 13° with the axis of the beam.

A neutral point, with complementary effects at opposite sides of it, was also exhibited by the beam. The angle enclosed by the axis of the beam, and a line drawn from the neutral point to the observer's eye, measured in the first instance 66°.

The windows of the laboratory were now opened for some minutes, a portion of the incense smoke being permitted to escape. On again darkening the room and turning on the beam, the line of vision to the neutral point was found to enclose with the axis of the beam an angle of 63°.

The windows were again opened for a few minutes, more of the smoke being permitted to escape. Measured as before, the angle referred to was found to be 54°.

This process was repeated three additional times; the neutral point was found to recede lower and lower down the beam, the angle between a line drawn from the eye to the neutral point and the axis of the beam falling successively from 54° to 49°, 43° and 33°.

The distances, roughly measured, of the neutral point from the lamp, corresponding to the foregoing series of observations, were these:—

1st observation	2	feet	2	inches.
2nd	"	2	"	6	"
3rd	"	2	"	10	"
4th	"	3	"	2	"
5th	"	3	"	7	"
6th	"	4	"	6	"

At the end of this series of experiments, the direction of maximum polarization had again become normal to the beam.

The laboratory was next filled with the fumes of gunpowder. In five successive experiments, corresponding to five different densities of the gunpowder smoke, the angles enclosed between the line of vision to the neutral point and the axis of the beam were 63°, 50°, 47°, 42°, and 38° respectively.

After the clouds of gunpowder had cleared away the laboratory was filled with the fumes of common resin, rendered so dense as to be very irritating to my lungs. The direction of maximum polarization enclosed in this case an angle of 12°, or thereabouts, with the axis of the beam. Looked at, as in the former instances, from a position near the electric lamp, *no neutral point* was observed throughout the entire extent of the beam.

When this beam was looked at normally through the selenite and Nicol, the ring system, though not brilliant, was distinct. Keeping the eye upon the plate of selenite and the line of vision normal, the windows were opened, the blinds remaining undrawn. The resinous fumes slowly diminished, and as they did so the ring system became paler. It finally disappeared. Continuing to look along the perpendicular, the rings revived, but now the colors were complementary to the former ones. *The neutral point had passed me in its motion down the beam consequent upon the attenuation of the fumes of resin.*

In the fumes of chlorid of ammonium substantially the same results were obtained as those just described. Sufficient I think has been here stated to illustrate the variability of the position of the neutral point. The explanation of the results will probably give new work to the undulatory theory.*

Before quitting the question of the reversal of the polarization by cloudy matter, I will make one or two additional observations. Some of the clouds formed in the experiments on the chemical action of light are astonishing as to form. The experimental tube is often divided into segments of dense cloud, separated from each other by nodes of finer matter. Looked at normally, as many as four reversals of the plane of polarization have been found in the tube in passing from node to segment, and from segment to node. With the fumes diffused in the laboratory, on the contrary, there was no change in the polarization along the normal, for here the necessary differences of cloud-texture did not exist.

Further. By a puff of tobacco smoke or of condensed steam blown into the illuminated beam, the brilliancy of the colors may be greatly augmented. But with different clouds two different effects are produced. For example, let the ring system observed in the common air be brought to its maximum strength, and then let an attenuated cloud of chlorid of ammonium be thrown into the beam at the point looked at; the ring system flashes out with augmented brilliancy, and the character of the polarization remains unchanged. This is also the case when phosphorus or sulphur is burned underneath the beam, so as to cause the fine particles of phosphoric acid or of sulphur to rise into the light. With the sulphur-fumes the brilliancy of the colors is exceedingly intensified; but in none of these cases is there any change in the character of the polarization.

But when a puff of aqueous cloud, or of the fumes of hydrochloric acid, hydriodic acid, or nitric acid is thrown into the beam, there is a complete reversal of the selenite tints. Each of these clouds twists the plane of polarization 90°. On these and kindred points experiments are still in progress.†

* Brewster has proved the variability of the position of the neutral point for skylight with the sun's altitude. Is not the proximate cause of this revealed by the foregoing experiments?

† Sir John Herschel has suggested to me that this change of the polarization from positive to negative may indicate a change from polarization by reflection to polarization by refraction. This thought repeatedly occurred to me while looking at the effects; but it will require much following up before it emerges into clearness.

The idea that the color of the sky is due to the action of finely divided matter, rendering the atmosphere a turbid medium, through which we look at the darkness of space, dates as far back as Leonardo da Vinci. Newton conceived the color to be due to exceedingly small water particles acting as thin plates. Goethe's experiments in connexion with this subject are well known and exceedingly instructive. One very striking observation of Goethe's referred to what is technically called "chill" by painters, which is due no doubt to extremely fine varnish particles interposed between the eye and a dark background. Clausius, in two very able memoirs, endeavored to connect the colors of the sky with suspended water-vesicles, and to show that the important observations of Forbes on condensing steam could also be thus accounted for. Bruecke's experiments on precipitated mastic were referred to in my last abstract. Helmholtz has ascribed the blueness of the eyes to the action of suspended particles. In an article written nearly nine years ago by myself, the colors of the peat smoke of the cabins of Killarney* and the colors of the sky were referred to one and the same cause, while a chapter of the "Glaciers of the Alps," published in 1860, is also devoted to this question. Roscoe, in connection with his truly beautiful experiments on the photographic power of sky-light, has also given various instances of the production of color by suspended particles. In the foregoing experiments the azure was produced in *air*, and exhibited a depth and purity far surpassing any thing that I have ever seen in mote-filled liquids. Its polarization, moreover, was *perfect*.

In his experiments on fluorescence, Professor Stokes had continually to separate the light reflected from the motes suspended in his liquids, the action of which he named "false dispersion," from the fluorescent light of the same liquids, which he ascribed to "true dispersion." In fact it is hardly possibly to obtain a liquid without motes, which polarize by reflection the light falling upon them, truly dispersed light being unpolarized. At p. 530 of his celebrated memoir "On the Change of the Refrangibility of Light," Prof. Stokes adduces some significant facts, and makes some noteworthy remarks, which bear upon our present subject. He notices more particularly a specimen of plate glass which, seen by reflected light, exhibited a blue which was exceedingly like an effect of fluorescence, but which, when properly examined, was found to be an instance of false dispersion. "It often struck me," he writes, "while engaged in these observations, that when the beam had a continuous appearance, the polarization was more nearly perfect than when it was sparkling, so as to force on the mind the conviction that it arose merely from motes.† Indeed in the

* I have sometimes quenched almost completely, by a Nicol, the light discharged normally from burning leaves in Hyde Park. The blue smoke from the *ignited end* of a cigar polarizes also, but not perfectly.

† The azure may be produced in the midst of a field of motes. By turning the Nicol, the interstitial blue may be completely quenched, the shining, and apparently unaffected motes, remaining masters of the field. A blue cloud, moreover, may be precipitated in the midst of the azure. An aqueous cloud thus precipitated reverses the polarization; but on the melting away of the cloud the azure and its polarization remain behind.

former case the polarization has often appeared perfect, or all but perfect. It is possible that this may in some measure have been due to the circumstance, that when a given quantity of light is diminished in a given ratio, the illumination is perceived with more difficulty when the light is diffused uniformly, than when it is spread over the same space, but collected into specks. Be this as it may, there was at least no tendency observed toward polarization in a plane perpendicular to the plane of reflection, when the suspended particles became finer, and therefore the beam more nearly continuous."

Through the courtesy of its owner, I have been permitted to see and to experiment with the piece of plate glass above referred to. Placed in front of the electric lamp, whether edgeways or transversely, it discharges bluish polarized light laterally, the color being by no means a bad imitation of the blue of the sky.

Prof. Stokes considers that this deportment may be invoked to decide the question of the direction of the vibrations of polarized light. On this point I would say, if it can be demonstrated that when the particles are small in comparison to the length of a wave of light, the vibrations of a ray reflected by such particles cannot be perpendicular to the vibrations of the incident light; then assuredly the experiments recorded in the foregoing communication decide the question in favor of Fresnel's assumption.

As stated above, almost all liquids have motes in them sufficiently numerous to polarize sensibly the light, and very beautiful effects may be obtained by simple artificial devices. When, for example, a cell of distilled water is placed in front of the electric lamp, and a slice of the beam permitted to pass through it, scarcely any polarized light is discharged, and scarcely any color produced with a plate of selenite. But while the beam is passing through it, if a bit of soap be agitated in the water above the beam, the moment the infinitesimal particles reach the beam the liquid sends forth laterally almost perfectly polarized light; and if the selenite be employed, vivid colors flash into existence. A still more brilliant result is obtained with mastic dissolved in a great excess of alcohol.

The selenite rings constitute an extremely delicate test as to the quantity of motes in a liquid. Commencing with distilled water, for example, a thickish beam of light is necessary to make the polarization of its motes sensible. A much thinner beam suffices for common water; while with Brücke's precipitated mastic, a beam too thin to produce any sensible effect with most other liquids, suffices to bring out vividly the selenite colors.—*Proc. Roy. Soc.*, xvii, 223, Jan., 1869.

2. *Note on the Formation and Phenomena of Clouds;* by JOHN TYNDALL.—It is well known that when a receiver filled with ordinary undried air is exhausted, a cloudiness, due to the precipitation of the aqueous vapor diffused in the air, is produced by the first few strokes of the pump. It is, as might be expected, possible to produce clouds in this way with the vapors of other liquids than water.

In the course of the experiments on the chemical action of light which have been already communicated in abstract to the Royal Society, I had frequent occasion to observe the precipitation of such clouds in the experimental tubes employed; indeed several days at a time have been devoted solely to the generation and examination of clouds formed by the sudden dilatation of the air in the experimental tubes.

The clouds were generated in two ways; one mode consisted in opening the passage between the filled experimental tube and the air-pump, and then simply dilating the air by working the pump. In the other, the experimental tube was connected with a vessel of suitable size, the passage between which and the experimental tube could be closed by a stopcock. This vessel was first exhausted; on turning the cock the air rushed from the experimental tube into the vessel, the precipitation of a cloud within the tube being a consequence of the transfer. Instead of a special vessel, the cylinders of the air-pump itself were usually employed for this purpose.

It was found possible, by shutting off the residue of air and vapor after each act of precipitation, and again exhausting the cylinders of the pump, to obtain with some substances, and without refilling the experimental tube, fifteen or twenty clouds in succession.

The clouds thus precipitated differed from each other in luminous energy, some shedding forth a mild white light, others flashing out with sudden and surprising brilliancy. This difference of action is, of course, to be referred to the different reflective energies of the particles of the clouds, which were produced by substances of very different refractive indices.

Different clouds, moreover, possess very different degrees of stability; some melt away rapidly, while others linger for minutes in the experimental tube, resting upon its bottom as they dissolve like a heap of snow. The particles of other clouds are trailed through the experimental tube as if they were moving through a viscous medium.

Nothing can exceed the splendor of the diffraction-phenomena exhibited by some of these clouds; the colors are best seen by looking along the experimental tube from a point above it, the face being turned towards the source of illumination. The differential motions introduced by friction against the interior surface of the tube often cause the colors to arrange themselves in distinct layers.

The difference in texture exhibited by different clouds caused me to look a little more closely than I had previously done into the mechanism of cloud-formation. A certain expansion is necessary to bring down the cloud; the moment before precipitation the mass of cooling air and vapor may be regarded as divided into a number of polyhedra, the particles along the bounding surfaces of which move in opposite directions when precipitation actually sets in. Every cloud-particle has consumed a polyhedron of vapor in its formation; and it is manifest that the size of the particle must depend, not only on the size of the vapor pholyhe-

dron, but also on the relation of the density of the vapor to that of its liquid. If the vapor were light, and the liquid heavy, other things being equal, the cloud-particle would be smaller than if the vapor were heavy and the liquid light. There would evidently be more shrinkage in the one case than in the other; these considerations were found valid throughout the experiment. The case of toluol may be taken as representative of a great number of others. The specific gravity of this liquid is 0·85, that of water being unity; the specific gravity of its vapor is 3·26, that of aqueous vapor being 0·6. Now, as the size of the cloud-particle is directly proportional to the specific gravity of the vapor, and inversely proportional to the specific gravity of the liquid, an easy calculation proves that, assuming the size of the vapor polyhedra in both cases to be the same, the size of the particle of toluol cloud must be more than six times that of the particle of aqueous cloud. It is probably impossible to test this question with numerical accuracy; but the comparative coarseness of the toluol cloud is strikingly manifest to the naked eye. The case is, as I have said, representative.

In fact, aqueous vapor is without a parallel in these particulars; it is not only the lightest of all vapors, in the common acceptation of that term, but the lightest of all gases except hydrogen and ammonia. To this circumstance the soft and tender beauty of the clouds of our atmosphere is mainly to be ascribed.

The *sphericity* of the cloud-particles may be immediately inferred from their deportment under the luminous beams. The light which they shed when spherical is *continuous:* but clouds may also be precipitated in solid flakes; and then the incessant sparkling of the cloud shows that its particles are *plates*, and not spheres. Some portions of the same cloud may be composed of spherical particles, others of flakes, the difference being at once manifested through the *calmness* of the one portion of the cloud, and the *uneasiness* of the other. The sparkling of such flakes reminded me of the plates of mica in the river Rhone at its entrance into the Lake of Geneva, when shone upon by a strong sun.—*Phil. Mag.*, IV, xxxviii, p. 156.

II. GEOLOGY.

1. *Artesian Well at Terre Haute, Ind.;* in a letter from Prof. A. Guyot to J. D. Dana.—I have received, through the kindness of Rev. George Morrison of Terre Haute, Indiana, the following very interesting record of the boring of an Artesian Well at that place, made under the direction and at the expense of Chauncey Rose, Esq. This gentleman deserves the thanks of the geologists for having carried the work to that extent of minuteness with a special view to be useful to science. The knowledge of the nature and succession of strata down to the depth where the geologist has no possible access, is of itself of considerable interest. The value of the record would be much enhanced if accompanied by some fossils, which would enable the geologist to establish the place of each stratum in the regular series of formations. But I

know that it is next to impossible to get any of real value for the purpose of such operations.

The temperature of the water at the bottom of the well, taken with Valferdin's thermometer or some other kind of reliable self-registering instrument, would be of great interest for establishing the rate of increase of the terrestrial temperature downward. As this can still be done I trust the opportunity will not be lost to furnish the science of the globe with one more fact relating to that important question.

Record of the Boring of the White Sulphur Artesian Well at Terre Haute, Indiana, made under the direction and at the expense of Chauncey Rose, Esq., of Terre Haute.

	Feet.	Inches.	
Sand and gravel, first,	150		
Fire clay,	1	6	
Brown slate,	2		
Soapstone,	11		
Coal,	4	00—168	6
Fire clay,	3	6	
Limestone,	2	1	
Fire clay,	3	2	
Brown limestone,	2		
Soapstone,	1	6	
Coal,		6—181	3
Fire clay,	3	2	
Salt water—Blue hard limestone,	2	6	
Hard pan,	8	6	
Soapstone,	10	5	
Coal,	2	00—207	10
Fire clay,	3		
Sandstone,	1		
Blue limestone,	2	4	
Dark blue rock,	2	6	
White sandstone,	3		
Fire clay,	5		
Shale,	2	4	
Soapstone,	2		
Blue limestone,	5	2	
Soapstone,	5		
Black shale,	4		
Blue sandstone,	6		
Black shale,	2		
Fire clay,	5	0—256	2
Gray sandstone,	10		
Coal,		9	
Fire clay,	2	5	
Blue rock,	3	4	
Black shale,	3		
Fire clay,	2	3	
Limestone,	4		
Fire clay,	5	10	
Limestone,	3	6	
Coal,	2	6—293	9
Fire clay,	1		
Sandstone,	28	3	
Fire clay,	7	2	
Blue sandstone,	27	—357	2
Slate,	9		
Blue sandstone,	29	1	
White sandstone,	8		

	Feet.	Inches.	
Slate,	36	2½	
Sandstone,	1	7½	
Blue slate,	15	9	
White slate,	10	2	
Salt water—white sandstone,	35	11½	
Soapstone,	43		
Blue slate,	28	7½	
White slate,	7	7	
Hard sandstone,	23	9	
Hard blackstone,	9	6	
White slate,	12		
More salt water and gas, hard sand rock,	127	½—746	5½
White limestone,	4	4	
White fire clay,	3	3	
White limestone,	30		
Hard gray sandstone,	10		
Blue limestone,	6	11—801	3½
Hard white sandstone,		9	
Hard blue sandstone,	3	6	
Blue clay,	3		
Hard gray sandstone,	2	3½	
Hard blue limestone,	3	3	
Hard sandstone,	110	5	
Soft sandstone,	7	3	
Blue slate,	5		
Blue hard sandstone,	411	2	
Blue soapstone,	34	10	
White grit sandstone,	117	2	
Hard blue slate,	48		
Brown sandstone,	89	11	
White coarse sandstone,	10	9	
Dark sandstone,	6	9	
Yellow sandstone,	44	2	
Hard flint,	15	8	
Clay limestone or shale,	70	2—1785	

840 feet, show of oil,
1276 " 9 inches, lubricating oil.
1335 " vein of fresh water.
1629 " 10 inches, oil vein.
1658 " blue sulphur water.
1710 " white sulphur water.
1768 " more white sulphur water.
1785 " large flow of white sulphur water, at the rate of 6,000 gallons an hour.

2. *Prof. W. P. Shimper's work on Vegetable Paleontology.**— This work may be considered as a complement to Prof. Pictet's treatise on animal Paleontology. But it is prepared on a more extensive and complete plan, containing not only the distinctive characters of genera, but also those of species, with critical remarks on most of the genera and species admitted by this justly celebrated author.

No book of this kind has ever been more needed than this admirable treatise; it fills a gap in scientific literature. Since the publication of the *Genera et Species plantarum fossilium* of Unger in 1850, vegetable paleontology has rapidly progressed and the number of species has nearly quadrupled. Moreover, Unger, adopting generally the published species without critically examining them, has given in his work merely brief descriptions which are of little advantage to the student who has not in his possession the publications of the original authors; while Prof. Shimper, in the preparation of his work, has examined and compared from original authors all the species admitted by them, and even has, at a great cost of time and labor, visited the more extensive collections of fossil plants of Europe in order to examine and compare the specimens on which the species were established.

We have moreover in Prof. Shimper's book, not only diagnoses of the genera and species which after examination have been found worth preserving, but also a great number of illustrations of the genera and the more interesting species described by the author.

The study of any branch of Natural History necessitates the use of a number of special works. But every branch is represented by treatises exposing its most essential characters, and serving as points of departure for the student, and at the same time as points of reference for the learned. Botanical paleontology has had no such treatise; and it is hence easily understood why Prof. Shimper's work is so gladly welcomed by European savants and why it should be equally well received by American paleontologists. For it contains the description of most of our American well ascertained species of fossil plants, and fills a want greatly felt among us, where the study of botanical paleontology is discouraged if not prevented by the total want of books on the subject.

The plan adopted by Prof. Shimper is as follows: After the introduction and general remarks, the first part has a chapter giving a historical review of the subject; another on the state of preservation of fossil plants; then one on the distribution of fossil plants according to the geological formations; on the principles to be followed in the determination of the fossil remains of plants; on the change perceivable in the vegetable kingdom since its first appearance until our actual epoch. Then follows a general review of the flora of various ages; a chapter on vegetable paleontology in its application to the climatology of the old world, and another on its application to geology. This, with a general classi-

* Traité de Paléontologie Végétale, 2 vols., large 8vo, with an atlas of 100 plates in large 4to.

fication of the stratified formations forms the first part of the book in 125 pages.

The second and essential part contains the descriptions of genera and species. In the first volume we have the cryptogams from the Fungi to the Filices inclusive. The third volume will contain, after the completion of the descriptions in a third part, a synoptical table of the various floras, indicating the order of their chronological succession and their mode of distribution in the various formations to which they belong; and, in the fourth part, a bibliographical index of vegetable paleontology from the beginning of the century to the present time.*

It would be possible to criticize some of the opinions of the European author, or to point out a few errors in the discrimination of our American species. But Prof. Shimper has come to his general conclusions from a peculiar point of view sustained by an immense array of facts, in whose examination we cannot follow him, and the few omissions and errors of descriptions remarked in his book will certainly be corrected at the end of the work. We have only therefore to thank the author for the benefit his admirable treatise will confer upon paleontological science, especially in our country, where as yet collections of fossil plants and of books on the subject are unattainable.

Prof. Shimper's treatise is written in French, in an elegant style, which though concise, is clear and easily understood. Only the diagnoses of his genera and species are in Latin. L.

3. *On the Physical Cause of the Motion of Glaciers;* by JAMES CROLL, of the Geological Survey of Scotland.†—I have just seen an abstract of a most interesting paper by the Reverend Canon Moseley "On the Mechanical Possibility of the Descent of Glaciers by their weight only," which was read before the Royal Society on the 7th of January last.‡ In that memoir he arrives at the conclusion that, owing to the great resistance offered by the solid ice to *shearing*, it is impossible that glaciers can descend by their weight alone.

"All the parts," he remarks, "of a glacier do not descend with a common motion; it moves faster at its surface than deeper down, and at the center of its surface than at its edges. It does not only come down bodily, but with different motions of its different parts; so that if a transverse section were made through it, the ice would be found to be moving differently at every point of that section. . . . . There is a constant displacement of the particles of the ice over one another and alongside one another, to which is opposed that force of resistance which is known in mechanics as *shearing-force*."

He determines by calculation the amount of shearing-force which must not be exceeded if the displacement of the particles is

* The details on the unpublished volume are translated from the Publishers' notice, L. B. Baillière et fils; adding that Prof. Shimper's treatise is published as marked above and that the price of each volume with fifty plates is 50*fr.*

† From the Philosophical Magazine for March, 1869.

‡ Proceedings of the Royal Soc., vol. xvii, p. 202.

to be effected by the weight of the ice alone. In the case of the Mer de Glace at the Tacul, the shearing-force of the ice must not exceed 1·3193 lb. per unit surface of one square inch, if that glacier descends merely by its weight, at the rate observed by Professor Tyndall. From experiments which he has made, he finds that the actual shearing-force of ice per unit surface is about 75 lbs. Consequently he concludes it is impossible that the motion of the glacier can be due to its weight alone; there must be some other force in addition to the weight impelling the ice forward. And he calculates that the amount of work performed by this unknown force is thirty-four times the amount performed by the weight of the glacier.

This is a most important conclusion. It is quite decisive against the generally received opinion regarding the descent of glaciers by their own weight.

But although it is thus demonstrated that glaciers cannot descend by means of their weight alone in the manner generally supposed, still, I venture to think that, notwithstanding the demonstration, gravitation after all may be the only force moving the ice.

The correctness of the above conclusion, that the weight of the ice is not a sufficient cause, depends upon the truth of a certain element taken for granted in the reasoning, viz: that the *shearing-force* of the molecules of the ice remains *constant*. If this force remains constant, then Canon Moseley's conclusion is undoubtedly correct, but not otherwise; for if a molecule should lose its shearing-force, though it were but for a moment, if no obstacle stood in front of the molecule, it would descend in virtue of its weight.

The fact that the shearing-force of a mass of ice is found to be constant does not prove that the same is the case in regard to the individual molecules. If we take a mass of molecules in the aggregate, the shearing-force of the mass taken thus collectively may remain absolutely constant, while at the same time each individual molecule may be suffering repeated momentary losses of shearing-force. This is so obvious as to require no further elucidation. The whole matter, therefore, resolves itself into this one question, as to whether or not the shearing-force of a crystalline molecule of ice remains constant. In the case of ordinary solid bodies we have no reason to conclude that the shearing-force of the molecules ever disappears, but in regard to ice it is very different.

If we analyze the process by which heat is conducted through ice, we shall find that we have reason to believe *that while a molecule of ice is in the act of transmitting the energy received (say from a fire), it loses for the moment its shearing-force if the temperature of the ice be not under* 32° F. If we apply heat to the end of a bar of iron, the molecules at the surface of the end have their temperatures raised. Molecule A at the surface, whose temperature has been raised, instantly commences to transfer to B a portion of the energy received. The tendency of this process is to lower the temperature of A and raise the temperature of B. B

then, with its temperature raised, begins to transfer the energy to C. The result here is the same; B tends to fall in temperature, and C to rise. This process goes on from molecule to molecule until the opposite end of the bar is reached. Here in this case the energy or heat applied to the end of the bar is transmitted from molecule to molecule under the form of *heat or temperature.* The energy applied to the bar does *not change its character; it passes right along from molecule to molecule under the form of heat or temperature.* But the nature of the process must be wholly different if the transference takes place through a bar of ice at the temperature of 32°. Suppose we apply the heat of the fire to the end of the bar of ice at 32°, the molecules of the ice cannot possibly have their temperatures raised in the least degree. How, then, can molecule A take on, *under the form of heat,* the energy received from the fire without being heated or having its *temperature* raised? The thing is impossible. The energy of the fire must appear in A under a different form from that of heat. The same process of reasoning is equally applicable to B. The molecule B cannot accept of the energy from A under the form of heat; it must receive it under some other form. The same must hold equally true of all the other molecules till we reach the opposite end of the bar of ice. And yet, strange to say, the last molecule transmits in the form of heat its energy to the objects beyond; for we find that the heat applied to one side of a piece of ice will affect the thermal pile on the opposite side.

The question is susceptible of a clear and definite answer. When heat is applied to a molecule of ice at 32°, the heat applied does not raise the temperature of the molecule, it is consumed in work against the cohesive forces binding the atoms or particles together into the crystalline form. The energy then must exist in the dissolved crystalline molecule, under the statical form of an affinity—crystalline affinity, or whatever else we may call it. That is to say, the energy then exists in the particles as a power or tendency to rush together again into the crystalline form, and the moment they are allowed to do so they give out the energy that was expended upon them in their separation. This energy, when it is thus given out again, assumes the dynamical form of heat; in other words, the molecule gives out *heat* in the act of freezing. The heat thus given out may be employed to meet the next adjoining molecule. The ice-molecules take on energy from a heated body by melting. The peculiar form of motion or energy called heat disappears in forcing the particles of the crystalline molecule separate, and for the time being exists in the form of a tendency in the separated particles to come together again into the crystalline form.

But it must be observed that although the crystalline molecule, when it is acting as a conductor, takes on energy under this form from the heated body, it exists in the molecule under such a form only during the moment of transmission; that is to say, the molecule is melted, but only for the moment. When B accepts of

the energy from A, the molecule A instantly assumes the crystalline form. B is now melted; and when C accepts of the energy from B, then B also in turn assumes the solid state. This process goes on from molecule to molecule till the energy is transmitted through to the opposite side and the ice is left in its original solid state. This is the *rationale* of Faraday's property of regelation.

This is no mere theory or hypothesis; it is a necessary consequence from known facts. We know that ice at 32° cannot take on energy from a heated body without melting; and we know also equally well that a slab of ice at 32°, notwithstanding this, still, as a mass, retains its solid state while the heat is being transmitted through it. This proves that every molecule resumes its crystalline form the moment after the energy is transferred over to the adjoining molecule.

This point being established, every difficulty regarding the descent of the glacier entirely disappears; for a molecule the moment that it assumes the fluid state is completely freed from shearing-force, and can descend by virtue of its own weight without any impediment. All that the molecule requires is simply room or space to advance in. If the molecule were in absolute contact with the adjoining molecule below, it would not descend unless it could push that molecule before it, which it probably would not be able to do. But the molecule actually has room in which to advance; for in passing from the solid to the liquid state its volume is diminished by about $\frac{1}{10}$, and it consequently can descend. True, when it again assumes the solid form it will regain its former volume; but the question is, will it go back to its old position? If we examine the matter thoroughly we shall find that it cannot. If there were only this one molecule affected by the heat, this molecule would certainly not descend; but all the molecules are similarly affected, although not all at the same moment of time.

Let us observe what takes place, say at the lower end of the glacier. The molecule A at the lower end, say, of the surface, receives heat from the sun's rays; it melts, and in melting not only loses its shearing-force and descends by its own weight, but it contracts also. B immediately above it is now, so far as A is concerned, at liberty to descend, and will do so the moment that it assumes the liquid state. A by this time has become solid and again fixed by shearing-force; but it is not fixed in its old position, but a little below where it was before. If B has not already passed into the fluid state in consequence of heat derived from the sun, the additional supply which it will receive from the solidifying of A will melt it. The moment that B becomes fluid it will descend till it reaches A. B then is solidified a little below its former position. The same process of reasoning is in a similar manner applicable to every molecule of the glacier. Each molecule of the glacier consequently descends step by step as it melts and solidifies, and hence the glacier, considered as a mass, is in a state of constant motion downward. The fact observed by Professor Tyndall that

there are certain planes in the ice along which melting takes place more readily than others will perhaps favor the descent of the glaciers.

We have in this theory a satisfactory explanation of the origin of "crevasses" in glaciers. Take, for example, the transverse crevasses formed at the point where an increase in the inclination of the glacier takes place. Suppose a change of inclination from, say, 4° to 8° in the bed of the glacier. The molecules on the slope of 8° will descend more rapidly than those above on the slope of 4°. A state of tension will therefore be induced at the point where the change of inclination occurs. The ice on the slope of 8° will tend to pull after it the mass of the glacier moving more slowly on the slope above. The pull being continued, the glacier will snap asunder the moment that the cohesion of the ice is overcome. The greater the change of inclination is, the more readily will the rupture of the ice take place. Every species of crevasse can be explained upon the same principle.

This theory explains also why a glacier moves at a greater rate during summer than during winter; for as the supply of heat to the glacier is greater during the former season than during the latter, the molecules will pass oftener into the liquid state.

As regards the denuding power of glaciers, I may observe that, though a glacier descends molecule by molecule, it will grind the rocky bed over which it moves as effectually as it would do did it slide down in a rigid mass in the way generally supposed; for the grinding-effect is produced not by the ice of the glacier, but by the stones, sand, and other materials forced along under it. But if all the resistances opposing the descent of a glacier, internal and external, are overcome by the mere weight of the ice alone, it can be proved that in the case of one descending with a given velocity the amount of work performed in forcing the grinding materials lying under the ice forward must be great, supposing the motion of the ice to be molecular, in the way I have explained, as it would be if the ice descended in the manner generally supposed.

Of course, a glacier could not descend by means of its weight as rapidly in the latter case as in the former; for in fact, as Canon Moseley has shown, it would not in the latter case descend at all; but assuming for the sake of argument the rate of descent in both cases to be the same, the conclusion I have stated would follow. Consequently whatever denuding effects may have been attributed to the glacier, according to the ordinary theory, must be equally attributable to it according to the present theory.

This theory, however, explains, what has always hitherto excited astonishment, viz: why a glacier can descend a slope almost horizontal, or why the ice can move off the face of a continent perfectly level.

Canon Moseley suggests that heat passing into the ice might by its mechanical energy, together with the weight of the glacier, be sufficient to account for the motion. But the mechanical energy of heat is not required to push the glacier forward; gravitation

alone, as we have seen, will suffice. Besides, heat entering ice could not produce a mechanical pressure that would move the glacier; for heat produces contraction of volume, not expansion. True, heat no doubt destroys the crystalline structure of the ice-molecule by tearing the constituent particles separate; but nevertheless the volume of the mass is diminished by this process, for ice in losing its crystalline structure, or, in other words, in passing from ice to water, decreases in volume.

4. *On some Reptilian remains;* by Prof. COPE, (Proc. Am. Phil. Soc., xi, 117.)—The fossil which Prof. Cope exhibited was the almost perfect cranium of a Mosasauroid reptile, the *Clidastes propython*. He explained various peculiarities of its structure, as the moveable articulation of certain of the mandibular pieces on each other, the suspension of the os-quadratum at the extremity of a cylinder composed of the opisthotic, &c., and other pecularities. He also explained, from specimens, the characters of a large new Plesiosauroid from Kansas, discovered by Wm. E. Webb, of Topeka, which possessed deeply biconcave vertebræ, and anchylosed neural arches, with the zygapophyses directed after the manner usual among vertebrates. The former was thus shown to belong to the true Sauropterygia, and not to the Streptosauria, of which Elasmosaurus was the type. Several distal caudals were anchylosed, without chevron bones, and of depressed form, while proximal caudals had anchylosed diapophyses and distinct chevron bones. The form was regarded as new, and called *Polycotylus latipinnis*, from the great relative stoutness of the paddle.

He also gave an account of the discovery, by Dr. Samuel Lockwood, of Keyport, of a fragment of a large Dinosaur, in the clay which underlies immediately the clay marls below the lower Green Sand bed in Monmouth county, N. J. The piece was the extremities of the tibia and fibula, with astragalo-calcaneum anchylosed to the former, in length about sixteen inches; distal width fourteen. The confluence of the first series of tarsal bones with each other, and with the tibia, he regarded as a most interesting peculiarity, and one only met with elsewhere in the reptile Compsognathus and in birds. He therefore referred the animal to the order Symphypoda, near to Compsognathus *Wagn.* The extremity of the fibula was free from, and received into, a cavity of the astragalo-calcaneum, and demonstrated what the speaker had already asserted, that the fibula of Ignanodon and Hadrosaurus had been inverted by their describers. The medullary cavity was filled with open cancellous tissue. The species, which was one half larger than the type specimen of *Hadrosaurus Foulkii*, he named *Ornithotarsus immanis.*

5. *Sulphur Deposits of the island of Saba, in the Dutch West Indies*, (from a Report on the Deposit, by N. S. HIGGINS.)—The Island of Saba belongs to the volcanic range of the Carribee or Windward Islands.

A few miles to the south and west of Saba there is an extensive coral reef, upon which soundings vary from 7 to 140 fathoms in depth; between this reef and the island there is practically no bot-

tom. The rock composing almost the entire formation of Saba is trachytic porphyry, which contains glassy feldspar (or orthoclase), and hornblende in crystals, disseminated through a dark reddish colored base. The formation upon the northward portion of the island in which the sulphur deposits exist, seems to have undergone a more rapid and thorough decomposition than upon the southward, or lee side; this is owing probably to its exposure to the trade winds. It is also more bluff, and the mountain sides more precipitous, a feature common to the northern and eastern portions of almost all of the Windward Islands, particularly those belonging to the volcanic series.

The sulphur deposit is located on the northern part of the Island of Saba, and extends from what is called "All too far Ridge" to "Flat Point," a distance of more than a mile along the sea line. Between these points the sulphur stratum can be traced, varying from 15 to 50 feet in thickness. Near "Flat Point" its elevation is probably not more than 45 feet above the sea level, while at or near "All to far Ridge" it has an elevation of about 200 feet from its foot wall.

III. ASTRONOMY.

1. *Prizes for the discovery of Comets.*—The following circular has been issued by the Imperial Academy of Sciences at Vienna.

For several years past there have been remarkably few discoveries of new comets. The cause of this fact, which seems inconsistent with that of the wider distribution of telescopes suitable for such discoveries, may be due to the special attention that has been given to the small planets. It is, however, much to be regretted that there has been such slight increase in our knowledge of the comets, in view of the recently established connection between the shooting stars and the comets. It is exceedingly desirable that we should know more than two or three hundred out of the many thousands of comets which undoubtedly belong to our system, especially as most of those which we know move in parabolic orbits. Were our knowledge of comets more complete we should surely know of more meteor streams and comets belonging one to the other. Mindful of Herr Schumacher's words, "it is natural that astronomers intrusted with the administration of a well furnished observatory should have no time left for sweeping the sky so minutely and so perseveringly as is necessary for discovering these faint bodies, whilst, on the contrary, it seems certain that to the many amateur astronomers who have less extensive means of observation hardly any more useful kind of activity could be recommended," the Imperial Academy of Sciences at Vienna is induced to propose for the discovery of comets during the next three years (from May 31st, 1869, to May 31st, 1872) eight prizes annually, consisting, as the receiver may choose, of a gold medal, or of twenty Austrian ducats representing its value in money.

The award of these prizes will be subject to the following regulations:

1. The prize will be given only for the first eight comets discovered in each of the three years named, and only for such comets as are telescopic at time of discovery, that is, invisible to the naked eye. The comet must not have been before seen by another observer, and must be one whose appearance could not securely be predicted.

2. The discovery must be communicated immediately and without waiting for further observations, to the Imperial Academy of Sciences, by telegraph if practicable; and otherwise by the earliest post. The Academy undertakes to transmit the news immediately to other observatories.

3. The time and place of discovery with the plan and course of the comet must be given as exactly as possible with the first notice. This first notice is to be supplemented by such later observations as may be made.

4. If the discovery should be confirmed by other observers the prize will not be awarded unless the observations of the discoverer suffice for the determination of the orbit.

5. The prizes will be awarded in the general meeting of the Academy held at the end of May of each year. In case the first notice of a discovery arrives between the first of January and the end of May, the final award of the prize will be deferred till the general meeting in May in the following year.

6. Application for the prize must be made to the Academy within five months from the time of the arrival of the first notice. Later applications will not be considered.

7. The Imperial Academy will procure the decision of the permanent astronomers of the Observatory at Vienna as to the fulfilment of the conditions in Nos. 1, 3, and 4.

2. *On the Phenomena of Light, Heat, and Sound accompanying the fall of Meteorites;* by W. Ritter v. Haidinger, For. Mem. R.S., &c.—A particular incident caused me to return to some portions of my earlier studies in regard to meteors and meteorites.

It was the fall of a meteorite at Kakowa on the 19th of May, 1858, that first induced me to bestow some more attention on this department of physical science. A report on the subject I laid before our Imperial Academy of Vienna on the 7th of January, 1859. On the same day also I gave the first list of the meteorites forming the meteorite collection in our Imperial Mineralogical Museum. A series of reports on meteorites followed, as well as a number of catalogues of meteorites, in accordance with the growing riches of the collection, embracing from 137 to 236 numbers of localities preserved up to the date of July 1, 1867.

But the studies relating to the recent fall of Ausson on the 9th of December, 1858, and the ancient fall of the meteoric iron of Hraschina, near Agram, on the 26th of May, 1751, others on the Cape meteorites of 1838, on those of Shalka, 1850, Allahabad, 1822, Quenggouk (Pegu), 1857, Assam, found 1846, Segowlee,

1853, St. Denis-Westrem, 1855, Nebraska, found 1856, but particularly some studies relating to meteorites of Stannern, 1858, and of that most remarkable meteoric iron from Tula, discovered in 1856 by Auerbach, all of them within the period of 1851 to 1860, and then the fall of New Concord, 1860, and of Parnallee, 1857, had forcibly called upon me to draw up, as it were, a general rule of the nature and succession of events which probably might have taken place in the history of their existence, though in each particular case only fragments of that history came to our notice.

A general survey of this kind I had the honor to lay before our Imperial Academy on the 14th of March, 1861, "On the nature of Meteorites, relating to their composition and the phenomena of their fall."* I felt, it is true, that I had rather too boldly ventured to transgress the limits of my former studies; but at the same time, led on by the high interest connected with the subject, I wished to gain some more publicity for it. As to England, I was most kindly and effectively patronized by that energetic promoter of meteoritic science, my most honored friend Mr. R. P. Greg. He laid a notice of mine before the British Association for the Advancement of Science, held that year at Manchester, and accompanied it with several considerations of his own;† then, also, he kindly had the pages of the Philosophical Magazine opened for me, and presented me with an edition of separate copies of a memoir on the subject—nearly a translation, by my honored friend Count A. F. Marchall, of my original communication to our Academy.‡

At the Meeting of German naturalists and physicians at Speyer, my honored friend Dr. Otto Buchner kindly called the attention of the friends of this department of natural science to my memoir, which had been favorably mentioned in the reports.

A note of mine, containing the leading views of my papers, was likewise laid by my honored friend M. Elie de Beaumont before the Paris Académie des Sciences in their Meeting of September 9th, 1861, while I also sent a French translation by my excellent friend Count Marchall, together with a copy of my original memoir.§

Since that time, up to this day, I had frequently, in seve al communications on meteoritic subjects, had an opportunity to re-

* "Ueber die Natur der Meteoriten in ihrer Zusammensetzung und Erscheinung," Sitzungsberichte der Kaiserlichen Akademie der Wissenchaften, der Mathem.-naturw. Classe, 1861, Band xliii. Abth. ii. S. 389-425.

† "An attempt to account for the Physical Condition and the Fall of Meteorites upon our Planet, by W. Haidinger, Hon. Memb. R.S.L. & E. &c.," Report 1861, Transactions of the Sections, p. 15. "Some Considerations on M. Haidinger's Communication on the Origin and Fall of Aërolites, by R. P. Greg, F.G.S.," ibid, p. 13.

‡ Considerations on the Phenomena attending the Fall of Meteorites on the Earth, by W. Haidinger, For. Memb. R.S.L. & E.; and Philosophical Magazine for November and December, 1861.

§ "De la nature des bolides et de leur mode de formation. Lettre de M. Haidinger," Comptes Rendus hebdomadaires des séances de l'Académie des Sciences, etc., t. liii. Juillet-Décembre 1861, pp. 456-461.

fer to these leading papers, and to support the views which they contained. Therefore I had every reason to be astonished when I read, in a recent work on meteorites by M. Stanislas Meunier,* the following assertion;—"We may observe that a great number of particular phenomena occurring in the fall of meteorites have hitherto remained without explanation. Thus the reason of the explosions, and particularly of the repeated explosions, that of the rumblings, that of the incandescence, are still absolutely unknown."†

But I had still more reason to be astonished when I found M. Daubrée himself nearly upon the same level in his views respecting the origin of light, heat, and sound in the fall of meteorites.

I certainly heartily appreciate the high merit of my honored friend M. Daubrée, in regard both to his deep studies on meteorites and his eminent success in forwarding the interests of the Paris Museum of Meteorites; but I at the same time may be permitted to consider my own views, as given in the memoirs quoted, as representing a scientific advance compared with the statements of M. Meunier and those of M. Daubrée himself in his last memoir on the Orgueil fall.‡ Neither M. Daubrée nor M. Meunier had refuted or even objected to my views; they had only passed them over in silence, doubtless because they had escaped their notice.

But I believe I am fulfilling a duty to scientific progress if I endeavor to place the discrepant and even contradictory views on these subjects together, in order once more to excite attention and recommend them to further study on the part of the votaries of natural science; and it was with this view that I prepared a new memoir, to be laid before our Imperial Academy in their approaching period of session, on the light, heat, and sound accompanying the fall of meteorites. I begin with some of the statements put forth by M. Daubrée, as taken from his memoir on Orgueil:—

"Things go on as if the greater part of the mass of the meteor got out of our atmosphere, in order to continue its course, after having left us some particles, the velocity of which, in consequence of the explosion, was reduced."§ M. Daubrée does not admit the arrival of groups or swarms of meteorites as has been asserted.‖ "The carbonaceous meteorites contradict the hypothe-

* Eutde, descriptive, théorique, et expérimentale sur les Météorites, par M. Stanislas Meunier. Paris, 1857, p. 18.

† "Remarquons qu'un grand nombre de particularités offertes par la chute des météorites sont restées jusqu'à présent sans explication. Ainsi, la cause des explosions et surtout des explosions multiples, celle des roulements, celle de l'incandescence, sont absolument inconnues."

‡ "Complément d'Observations sur la chute de météorites qui a eu lieu le 14 Mai 1864 aux environs d'Orgueil," Nouvelles Archives du Muséum d'Histoire Naturelle, t. iii, pp. 1–19.

§ "Les choses se passent donc comme si la plus grande partie de la masse météorique ressortait de l'atmosphère pour continuer sa trajectoire, n'abandonnant que quelques parcelles dont la vitesse, à la suite de l'explosion, se trouvait amortie."—*Op. cit.* p. 15.

‖ Comme on l'a dit.

sis that the heat of the meteorites is due to the loss of their *vis viva.*"* The sounds, detonations under the name of explosions, remain without explanation.†

M. Daubrée attributes to mere chance the situation of what he calls "scales," or "écailles de météorites," at the moment of an explosion, if they present certain particular seams of crust surrounding their most extended surface, by which, being foremost, they forced their way through the opposing atmosphere. In regard to this position I had long ago advanced that it must have been a necessary result, while the rectilinear movement of the meteorite was in the way of being checked, of part of the force having been expended in producing a rotatory motion perpendicular to the direction of the course. This I did in particular, in a paper on the meteoric iron of Hraschina, on the 14th of April, 1859, then on an aërolite from Stannern on the 22nd of May, 1862, and in other instances.

The above-mentioned quotations of M. Daubrée's views are now compared with the successive periods of progress in the fall of meteorites, nearly in the same words as I proposed them in 1861.

In the arrival of meteorites on our earth:—

1. Single or agglomerated fragments, in their cosmical course, come into contact with our globe.
2. The fragments are arrested by the resistance of atmospheric air.
3. Pressure, in their progress through the atmospheric air, elicits light and heat; rotation ensues, and a melted crust is formed.
4. The white-hot compressed air is spread out in the form of a fireball, closed up behind, and enclosing the fragment, or fragments, and a vacuum-space.
5. The cosmic course is at an end when the fragment, or the fragments, have been arrested by air.
6. Light and heat are no longer generated; the vacuum-ball will collapse with a loud report, or several reports following each other.
7. The cosmic cold within the aërolite assists in reducing the heat of the melted crust.
8. The meteorite falls down upon the earth like any other ponderous body, the hotter the better conducting material it consists of.

In this way I believe it was my duty again to lay before the public the differences of the views newly taken by M. Daubrée from those which I hitherto had advocated.

But while I was engaged in contrasting them I found myself conspicuously supported by a number of recent publications relative to the subject in question. In one of his own papers M. Daubrée had to register the statement of M. Leymerie, of Toulouse, who considered the fall of Orgueil as presenting not one meteoric mass exploded, but a swarm of aërolites arrived at the same moment.

* "Les météorites charbonneuses contredisent l'hypothèse que la chaleur des météorites est due à la perte de leur force vive."—*Op. cit.*, p. 8.

† "Sans explication."—*Op. cit.*, p. 16.

But above all, two reports of the fall of 30th January, 1868, near Pultusk, both of them kindly presented to me by their respective authors, bore ample testimony in favor of a number of my theses, and enlarged them by deeper and more accurate investigation beyond what I formerly proposed.

These are the memoir "On the Course of the Pultusk Meteorite,"* by Professor J. G. Galle in Breslau, and another, "On the Meteorites of Pultusk,"† by Professor G. vom Rath, in Bonn.

In both of them the most evident proofs are given of the actuality of a swarm, consisting of a very great number of distinct aërolites, having entered our atmosphere.

The course of the Pultusk meteor, according to M. Galle, met the horizontal line under an angle of 44 degrees at the place of dispersion, at a height of 25·25 English miles, or 5½ German miles. After its movement was checked, and the force of it expended in the development of light and heat, how would it have been possible that, as it would follow from M. Daubrée's supposition, the great mass of the meteor should have risen again and left our atmosphere to continue its cosmical orbit? Nor could such be the case with the Knyahinya meteor, which pounced upon our earth almost from the zenith of the place, the course making an angle only of 6 degrees with the perpendicular. But even the Orgueil meteor moved in a direction meeting the horizontal line at the point of dispersion under an angle of about 11° 26′, from which position it certainly could not rise again higher up into the atmosphere, and still less leave it altogether.

I availed myself of the circumstance that I had been gratified by several honored friends with a number of important publications closely connected with the subject, to quote some appropriate passages. I would refer especially to that grand 'Atlas of Charts of Meteor-tracks,' by Messrs. R. P. Greg and A. S. Herschel,‡ together with the "Reports of Luminous Meteors for the years 1865 and 1866–1867,"§ and to the recent memoir by M. G. V. Schiaparelli on the astronomical theory of falling stars,‖ kindly

* Ueber die Bahn des am 30. Januar 1868 beobachteten und bei Pultusk im Königreiche Polen als Steinregen niedergefallenen Meteors durch die Atmosphäre. Vom Professor Dr. C. G. Galle, Direktor der Sternwarte zu Breslau. Vorgetragen am 4. März u. s. w. Besonderer Abdruck aus den Abhandlungen der Schlesischen Gesellschaft für vaterländische Cultur. Breslau, 1868.

† Ueber die Meteoriten von Pultusk im Königreiche Polen gefallen am 30. Januar 1868. Von Dr. G. vom Rath. Mit einer Tafel. Besonders abgedruckt aus der Fest schrift der Niederrheinischen Gesellschaft für Natur- und Heilkunde zum 50 jährigen Jubiläum der Universität Bonn.

‡ 'Atlas of Charts of the Meteor-tracks contained in the British Association Catalogue of Observation of Luminous Meteors, extending over the years from 1845 to 1866, &c.' Prepared for the Luminous-Meteors Committee of the British Association by R. P. Greg and A. S. Herschel.

§ Report on Observations of Luminous Meteors, 1865-66, by a Committee consisting of James Glaisher, F.R.S., of the Royal Observatory, Greenwich, Secretary to the British Meteorological Society; Robert P. Greg, F.G.S.; E. W. Brayley, F.R.S.; and Alexander Herschel, B.A. From the Report of the British Association for the Advancement of Science for 1866. The same for 1866–1867.

‖ 'Note e riflessioni intorno alla teori astronomica delle Stelle Cadenti.' From the work 'Memorie di Matematica e di Fisica della Società Italiana delle Scienze fondata da Anton Mario Lorgna,' ser. 3, tomo i, parte 1, p. 153, Firenze, 1867.

sent to me by the late lamented Matteucci. Schiaparelli holds forth that in shooting stars "the *vis viva*, while the meteoric matter is dispersed in the atmosphere, is completely destroyed by being transformed into heat and light."* From Mr. A. S. Herschel's observations with the spectroscope, we learn that the condition of the August meteors is exactly that of a flame of gas in a Bunsen's burner freely charged with the vapor of burning sodium, or of the flame of a spirit-lamp newly trimmed and largely dosed with a supply of moistened salt (*op. cit.*, p. 146). The idea of a diminutive fireball containing the solid mass, although diminutive itself, surrounded by a luminous gaseous case, including a vacuum, till the force of the movement is spent in heat and light, may not be considered inadequate to the subject.

In a most interesting memoir entitled "Contributions to the Knowledge of Falling Stars,"† by Dr. Edmond Weiss, of Vienna, that able astronomer (the representative, together with Dr. Oppolzer and Lieut. Reziha, of the Austrian Navy, of our Austrian expedition for the eclipse of 18th of August at Aden, where they were so hospitably welcomed and kindly supported by the Governor-General, J. Russel, in behalf of the British Government, along with the North-German expedition, composed of Drs. Vogel, Fritsche, Zenker, and Thiele) considers among other subjects the influence of the earth's attraction upon shower-meteors, independently of Schiaparelli's disquisitions relative to the same subject, and points out also the circumstance that some of them may receive such a direction as to leave our solar system altogether, while Dr. Galle insists upon the fact that the Pultusk swarm must have entered it with an independent force of at least from $4\frac{1}{2}$ to 7 English miles (1 to $1\frac{1}{2}$ geographical miles).

My original design was only to offer some appropriate remarks on the subject of the phenomena of light, heat, and sound generated in and accompanying the arrival of meteorites on the earth through our terrestrial atmosphere; but the different departments of natural science referring to meteors and meteorites are of so manifold a nature, that I frequently was obliged to advert to some of them in regard to which I should rather have kept more on the reserve. But the whole range of meteor- and meteorite-science, continually enlarging, more and more clearly presents itself in these four grand sections:—1st, the original formation of meteorites; 2nd, their movement through cosmic space; 3rd, their arrival through the atmosphere upon our earth; and, 4th, the studies instituted on the objects themselves, which fall into our hands and are preserved in our museums. To the third of these sections it is that my particular attention was directed.—*Proc. Roy. Soc.*, xvii, 155.

* "Questa forza viva, dileguandosi la materia meteorica nell' atmosfera, viene completamente distrutta trasformandosi in calore ed in luce."—*Op. cit.* p. 198.

† "Beiträge zur Kenntniss der Sternschnuppen, von dem c. M. Dr. Edmund Weiss. Vorgelegt in der Sitzung am 16. Jänner 1868," Sitzungsberichte der Math.-nat. Classe der Kais. Akademie der Wissenschaften, lvii, Band ii, Abth. 5. pp. 281–342.

3. *Note on the Heat of the Stars;* by WILLIAM HUGGINS, F.R.S. —In the summer of 1866 it occurred to me that the heat received on the earth from the stars might possibly be more easily detected than the solar heat reflected from the moon. Mr. Becker (of Messrs. Elliot Brothers) prepared for me several thermopiles, and a very sensitive galvanometer. Toward the close of that year, and during the early part of 1867, I made numerous observations on the moon, and on three or four fixed stars. I succeeded in obtaining trustworthy indications of stellar heat in the case of the stars Sirius, Pollux, and Regulus, though I was not able to make any quantitative estimate of their calorific power.

After describing the mode of making his observations with an astatic galvanometer, he observes:

The mean of a number of observations of Sirius, which did not differ greatly from each other, gives a deflection of the needle of 2°.

The observations of Pollux 1½°.

No effect was produced on the needle by Castor.

Regulus gave a deflection of 3°.

In one observation Arcturus deflected the needle 3° in 15 minutes.

The observations of the full moon were not accordant. On one night a sensible effect was shown by the needle; but at another time the indications of heat were excessively small, and not sufficiently uniform to be trustworthy.

It should be stated that several times anomalous indications were observed, which were not traced to the disturbing cause.

The results are not strictly comparable, as it is not certain that the sensitiveness of the galvanometer was exactly the same in all the observations, still it was probably not greatly different.

Observations of the heat of the stars, if strictly comparable, might be of value, in connexion with the spectra of their light, to help us to determine the condition of the matter from which the light was emitted in different stars.

4. *The Total Eclipse of August* 7, 1869.—Few astronomical phenomena have probably ever called out a more thoroughly organized system of observation than that arranged for the recent eclipse. The line of total obscuration crossed the North American continent diagonally, entering the territory of the United States at Behring's Straits, in about the 65th degree of latitude, and longitude 90° west of Washington, while it left our shore at the latitude of 34° and the meridian of Washington itself. It traversed a central belt of well-populated territory, yet there seems to have been scarcely a town of any considerable magnitude along the entire line which was not garrisoned by observers having some special astronomical problem in view.

An appropriation was made by Congress, at its last session, for carrying out a series of observations under the direction of the Superintendent of the Nautical Almanac, and Prof. Coffin has succeeded, by the liberal aid of the Navy Department and the very generous and extensive facilities contributed by some of the principal railroads, in providing for an amount of work which for mag-

nitude, variety and thoroughness seems large beyond all proportion to the sum placed at his disposal. Three cities in Iowa, Burlington, Mount Pleasant and Ottumwa, were occupied by astronomical, photographic and physical observers under his direction, and special observers, provided with telescopes and instruments for determining geographical position, were sent by him to the North and South, to fix the limits of the belt of total obscuration.

The Navy Department, besides making other provisions, sent observers to the western shore of Behring's Straits; and the War Department detailed Dr. Curtis, to make special photographic observations at Des Moines, Iowa.

The Coast Survey established parties on the Yaken river in Alaska, at Des Moines in Iowa, Springfield in Illinois, and Abingdon in West Virginia, and perhaps at still other stations,—that at Springfield being amply provided with photographic observers and apparatus.

Most of the principal observatories likewise organized expeditions of greater or less magnitude. From Washington, the several observers arranged independent series of investigations, stellar, spectroscopic, physical and meteorological. From Cambridge a large party went to Shelbyville, Ky., with large photographic outfit and spectroscopic equipments. From Albany a similar party went to Mattoon, Illinois; others from Clinton and Chicago went to Des Moines, from Cincinnati to Sioux City; and the number of private astronomers who established themselves along the central line, with telescopes and other apparatus of investigation, must have been exceedingly large.

The weather for two days preceding had been unpromising, and in many places almost disheartening; but the efforts of the astronomers were at last rewarded by a day of almost cloudless serenity, with an atmosphere much more transparent than usual, in consequence of the copious rains; and so far as we have heard, the sky was favorable every where, unless a slight haze at Des Moines formed an exception.

It is of course too early, as we go to press, to give any general account of the results, which in most cases are not yet elaborated by the observers; but some matters of interest have been already made known.

The beginning and end of the eclipse seem to have been observed a few seconds later, and the beginning and end of the totality about fifteen seconds later than the predictions of the American Nautical Almanac. As regards the exact position of the central line, and of the limits of the total belt, we have as yet insufficient information to determine the degree of accordance with computation. There can be no doubt that materials have been collected capable of improving the adopted values of the moon's diameter and horizontal parallax.

One of the most interesting results is the introduction of a new and accurate method of determining the time of first contact, by observing with a spectroscope the gradual occultation of the bright lines of the chromosphere. This we owe to Prof. Young, of Dart-

mouth College, who formed one of Prof. Coffin's Nautical Almanac party at Burlington. By keeping the center of the slit directed to the point at which the contact is to take place, the observer is forewarned of the approach of the moon's limb, by the shortening of the bright lines belonging to the chromosphere. The line C is well adapted to this purpose, and is seen to grow steadily shorter until it is totally extinguished. The moment of disappearance of the last bright ray is of course that of the first contact, which is thus observed with the same care and accuracy as any other appulsive phenomenon. Although the first contact, as determined in this way by Prof. Young, was noted some five seconds before its recognition by any other observer, it was subsequently found by Prof. Mayer to accord within a small portion of a second with the time as determined by measurement of a series of photographs, taken during the first minute.

Prof. Young also determined the position of nine bright lines during the totality. These corresponded to 694, 1017·5, 1250±20, 1350±20, 1474, 2080, 2602±2, 2796 of Kirchhoff's scale, and the line *h*. (The lines *b* were seen elsewhere, but this region was not scrutinized by Prof. Young.) Of those named, the 1st, 6th, 8th and 9th are the hydrogen lines α, β, γ, δ, respectively; the 2d is near D but are refrangible, and was very bright; the 3d and 4th are new, but faint and their position estimated; the 5th is given by both Kirchhoff and Angström as an iron line; the 7th was also faint, and is new, its place being micrometrically determined from 2796.

Of these Prof. Young states that all but three belong to the protuberances; but the 5th certainly, and the 3d and 4th probably, to the corona only, remaining visible when the image of the protuberances was moved away from the slit, and the other lines disappeared. He also finds that certainly one of the lines in the corona-spectrum, (1474), and probably two others are coincident with auroral lines seen by Prof. Winlock at Cambridge, and reported in the last No. of this Journal.

Prof. Harkness, of Washington Observatory, observed at Des Moines the spectra of five protuberances, no two of which gave the same lines. In the corona spectrum he found no absorptive lines, and but one bright line.

Measures of the protuberances were made by Prof. Rogers, at Des Moines, who found the largest to be nearly a minute and a half high, and observed a peculiar honeycombed or cellular appearance in all of them.

Special search was made for intra-Mercurial planets by Prof. Newcomb, at Des Moines, according to the plan suggested by him in the April No. of this Journal, with two 6-inch object-glasses, having a field of about 20′ each, and previously clamped to the desired position. A similar scrutiny of the ecliptic near the sun was made by Dr. Gould, at Burlington, in connection with Prof. Coffin's party, using a Tolles telescope of five inches aperture and a field of nearly 2°, provided with occulting discs at the focus. But

neither of these observers nor any others engaged in similar research, found any indications of planets nearer than Mercury.

The photographic observations were very numerous and successful. At Burlington eight impressions are reported to have been taken during totality, by the Nautical Almanac party, and several by the parties at Des Moines, Springfield and Shelbyville. The total number during the partial taken must have been many hundreds.

In our next issue we hope to give more accurate and complete accounts, together with original reports. G.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Eighteenth Meeting of the American Association for the Advancement of Science, held in Salem, Massachusetts, Aug.* 18–26, 1869.—The Salem meeting of the American Association, under the Presidency of J. M. FOSTER of Chicago, was well attended from all parts of the country. About two hundred and fifty old members from a distance recorded their names as in attendance, and over one hundred and fifty new members were elected. The number of communications entered upon the daily programmes of the Standing Committee was about one hundred and fifty, a full list of the titles of which is appended. The range of these papers was considerable, and it was found expedient to have sub-sections on Archeology and Microscopy, to facilitate the disposal of papers which could not be reached in the other sections.

The recent total eclipse of the sun, (Aug. 7th), was naturally a prominent subject of interest. The astronomers were present in considerable force, and the whole of Monday, the 23d, was devoted in Section A to the discussion of this subject. For a notice of the main points of interest then brought out, reference may be had to the preceding article on this subject.

The dedication of the Peabody Academy of Science, on Wednesday, the 18th of August, was an occasion of interest, worthy to occupy the attention of the Association at its opening session. This Institution was founded at Salem in the year 1867, by the munificence of George Peabody, with the design of promoting the study of science in his native county of Essex. The first Annual Report of the Trustees of this Academy, made in January, 1869, shows that it is already fully organized, with an able corps of officers and a well ordered museum, library, &c., and the activity of its Director and Curators is evident not only in the extent and fine condition of the collections but in the zeal and ability with which the various publications of the Academy are conducted. Advantage was taken of the present occasion to make the formal transfer of the building of the Museum to the Trustees, and its delivery and acceptance by the Director, F. W. PUTNAM. In an eloquent address the President of the Academy, WILLIAM C. ENDICOTT, Esq., gave the history of the Museum from its foundation, in 1801, as the East India Marine Hall, to its purchase and reorganization in its present form. The Essex Institute, which is well

known by its Proceedings, Bulletin and Historical Collections, is now incorporated with the Peabody Academy of Science.

The address of Dr. B. A. Gould, the retiring President of the Association, was given on Friday evening, (Aug. 20). His theme was the Position of Men of Science in America, and it was treated in his usual felicitous manner.

Every thing which a hearty good will and an intelligent appreciation of science could do was done to promote the happiness and forward the plans of the Association and its members, alike by the city authorities of Salem, the various scientific bodies, and private individuals. The weather was delightful, and every opportunity was embraced for excursions in the neighborhood by land and water. On Saturday the whole Association were the guests of the city government of Salem, on an excursion by steamboat through the bay of Salem and the waters of Boston harbor, visiting the famous Light House built by General Totten on Minott's Ledge, eighteen miles from land, in a situation as perilous and difficult as the famous Eddystone Light;—Fort Warren, notorious as the unwilling home of many prisoners of eminence during the late war,—and Nahant, where ample provisions were made for the entertainment of the numerous guests in pavilions and along the shores.

The sessions closed with a field day, under the auspices of the Local Committee and the members of the Peabody Academy.

The Association stands adjourned to meet on the first Wednesday in August, 1870, at Troy, New York, under the Presidency of WILLIAM CHAUVENET, of St. Louis University.

The following is a list of the papers read at the meeting.*

1. SECTION A. *Mathematics, Physics and Chemistry.*

On the Total Eclipse of Aug., 1869; B. PEIRCE.

On Quintuple Algebra; B. PIERCE.

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* The titles given above are only those which appeared on the daily official programmes, and some of these were read only by title.

The Volumetric determination of Carbonic Acid; C. A. SEELY.

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On some newly discovered properties of Phosphoric acid; E. N. HORSFORD.

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Causes of the Failure of Lightning Rods; J. BUSHEE.

Conditions of a Perfect Lightning Rod; J. BUSHEE.

On the demonstration of Euclid's assumption relative to Parallels; A. C. TWINING.

Some results of the discussion of the Boston Dry Dock Tide Observations; WM. FERREL.

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Hints toward an explanation of the Corona in Solar Eclipses; D. MURRAY.

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A self-recording Psychrometer; S. D. TILLMAN.

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A new method of observing contacts at a Solar Eclipse by the Spectroscope; C. A. YOUNG.

The Spectrum of the Solar Prominences and Corona, as observed at Burlington, Iowa, in the last Solar Eclipse, and the coincidence between the bright lines of Corona Spectrum and those of the Spectrum of the Aurora Borealis; C. A. YOUNG.

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On the Conservation of Force; H. F. WALLING.

Elemental Fibres, illustrated by models; H. F. WALLING.

Remarkable case of Freezing Fresh water Pipes in Salt water; W. W. WHEILDEN.

The Thermodynamics of Waterfalls; A. M. MAYER.

On some further evidence of the existence of a System of Arctic Winds; J. H. COFFIN.

The imperfect Whiteness of Snow; J. E. OLLIVER.

The present condition of Light House Illumination in the U. S.; JOSEPH HENRY.

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Smith's Vulcanite Electrical Machine, with attached condenser; M. G. FARMER.

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The reactive Force of a mass composed of many non-cohering particles or parts; J. D. WARNER.

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Photographing objects of natural size without a Camera; T. GAFFIELD.
Laws of Trade; E. B. ELLIOT.
The Proper Monetary Unit; J. F. HOLTON.
On the Abolition of Months; J. F. HOLTON.
The Numerical Method of Criticism; T. M. COAN.

2. SECTION B. *Geology and Natural History.*

Comparison of the Coral Faunæ of the Atlantic and Pacific Coasts of the Isthmus of Darien, as bearing on the supposed former connection between the two Oceans; A. E. VERRILL.
On certain Peculiarities in the distribution of marine life on the Sea-bottom of the Bay of Fundy; A. E. VERRILL.
American Phyllopod Crustacea; A. E. VERRILL.
Physical Geography and Geology of Brazil; CH. F. HARTT.
On Brazilian Drift; CH. F. HARTT.
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Observations on a New Genus of Polyzoa; A. HYATT.
New Species of Fishes obtained by Prof. Orton in the valleys of the Maranon and Napo; T. GILL.
On the systematic relations of the Lamarckian Pteroceræ; T. GILL.
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On the Dyestone Fossil Iron Ore in Pennsylvania; J. P. KIMBALL.
On the age and relations of the Metamorphic Rocks of New Brunswick and Maine; G. F. MATTHEW and L. W. BAILEY.
On the Raritan Clays of New Jersey; J. S. NEWBERRY.
On some recent Geological changes in Northeastern Wisconsin. (Communicated by G. R. STUNTZ); J. S. NEWBERRY.
Notice of some new Fossil Plants from Gaspé, discovered by Prof. J. W. DAWSON; J. S. NEWBERRY.
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Preliminary notice of the Lamellibranchiates of the Upper Helderberg, Hamilton and Chemung Groups; J. HALL.
Note on a phase in the reproduction of a Confervaceous Alga belonging to the genus Œdogonium; A. M. EDWARDS.
On the Classification of the Diurnal Lepidoptera; S. H. SCUDDER.
The Morphology of the Abdominal Appendages of Butterflies; S. H. SCUDDER.
The value of the characters drawn from the external Armature of Lepidopterous Larvæ; S. H. SCUDDER.
A Classification of the Eggs of Butterflies; S. H. SCUDDER.
Two new genera of Extinct Cetacea; E. D. COPE.
On Embryonic characters in American Salamanders; E. D. COPE.
Early stages of Brachiopods; E. S. MORSE.
Discovery of the Ammonoosuc Gold Field; H. WURTZ.
Note upon the Palæotrochis; H. WURTZ.
Notes on the Geology of Hoboken; H. WURTZ.
Studies of the Red Sandstone of New Jersey; H. WURTZ.
The Ammonoosuc Gold Field in New Hampshire and Vermont; C. H. HITCHCOCK.
The Gems of the United States; A. C. HAMLIN.
On the laws which govern the production of Sexes in Plants; T. MEEHAN.
Nature of the Glands in Acacia; T. MEEHAN.
On a remarkable locality of Vertebrate Remains in the Tertiary of Nebraska; O. C. MARSH.
Notices of some new Tertiary and Cretaceous Fishes; O C. MARSH.
Metamorphosis of Siredon into Amblystoma; O. C. MARSH.
On some new Mosasauroid Reptiles from the Greensand of New Jersey; O. C. MARSH.
Homologies of the Palæchinidæ; ALEX. E. R. AGASSIZ.
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Plumage of Terns, by Miss GRACE ANNA LEWIS; F. W. PUTNAM.

Geology and Physical Geography of a part of the coast of Maine; J. JOHNSTON.

On the Valley of the Amazon; J. ORTON.

Distribution of Coal, Iron and the Precious Metals in China; A. S. BICKMORE.

On the Non-fossiliferous Rocks of New England; N. T. TRUE.

On Surface Changes in Maine indicating the length of time since the close of the Quaternary Period; N. T. TRUE.

Compression as an agent in geological metamorphism, with illustrations of distorted pebbles in conglomerates; G. L. VOSE.

On the Plasticity of Pebbles and Rocks; W. P. BLAKE.

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Summary of results of a late Geological Reconnoissance of Louisiana; E. W. HILGARD.

Geology of Venezuela; R. P. STEVENS.

The Rocky Mountain Alpine Region; C. C. PARRY.

On Norite or Labradorite Rock; T. STERRY HUNT.

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Post-Glacial Fossils at Hoboken, N. J.; R. P. STEVENS.

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On the relations of the Geology of Ohio to that of the adjoining States; J. S. NEWBERRY.

Trend of the Rocky Mountain Range north of latitude 60°, and its influence on Faunal Distribution; WM. H. DALL.

On new species of Fishes obtained by Prof. Orton in the Valleys of the Maranon and Napo; T. GILL.

3. SUB-SECTION C. *Archeology and Ethnology.*

Indian Migrations. In four sections: Sec. 1. Physical Geography of North America, with reference to natural Highways; and means of Natural Subsistence afforded by its Areas. Sec. 2. Agricultural Subsistence, and the character and extent of Indian Agriculture. Sec. 3. Migrations of Roving and partially Village Indians, deduced from languages, traditions, and known migrations. Sec. 4. Migrations of Village Indians, as deduced from the same sources; L. H. MORGAN.

A conjectural explanation of the uses of the Embankments of the Mound Builders; L. H. MORGAN.

Discovery of the remains of the Horse among the Ancient Ruins of Central America; O. C. MARSH.

Physical Geography among the Aborigines of North America; N. T. TRUE.

On the Arrowheads of the American Indians and Aborigines. Illustrated by specimens; JOHN A. WARDER.

Exhibition of a few interesting implements collected by R. W. HASKINS from Indian graves on the banks of the Ohio, with special reference to the boring of holes in stone implements; F. W. PUTNAM.

Observations on the Languages of South America and the Classification of the Indian Nations thereof; P. C. BLISS.

The Constitution of man as modified by Light, Heat, and Cold; C. ROESEVELT.

On the Botocudos of Brazil; CH. F. HARTT.

The Ainos, or Hairy Men of Yesso, Saghalien and the Kurile Islands; A. S. BICKMORE.

Evidences of high antiquity in the Kjœkkenmœdden Deposits of New England; E. S. MORSE.

4. SUB-SECTION D. *Microscopy.*

Note on a phase in the Reproduction of a Confervaceous Alga belonging to the genus Œdogonium; A. M. EDWARDS.

On the resolution of Microscopic Test Objects; A. M. EDWARDS.

Some remarks on the Infusorial Deposits of North America; A. M. EDWARDS.

On Cleaning Guanos so as to obtain the Microscopic Organisms in them; A. M. EDWARDS.

Some remarks on an "Opaque Illuminator," applied to an Immersion Objective, and an Immersion Objective of Long Focal Distance; E. BICKNELL.

2. *Large Trees in Australia.*—On this subject the government director of the Botanic Garden at Melbourne furnishes some interesting details, as follows:—"The marvellous height of some of the Australian, and especially the Victorian, trees, has become the subject of closer investigation, since of late—particularly through the miners' tracks—easier access has been afforded to the back-gullies of our mountain system. Some astounding data, supported by actual measurements, are now on record. The highest tree previously known was a *Karri-Eucalyptus* (*Eucalyptus collossea*), measured by Mr. Pemberton Walcott, in one of the delightful glens of the Warren river in Western Australia, where it rises to approximately 400 feet high. Into the hollow trunk of this Karri, three riders, with an additional packhorse, could enter and turn in it without dismounting. At the desire of the writer of those pages (Dr. Mueller), Mr. D. Bogle measured a fallen tree of *Eucalyptus amydalina*, in the deep recesses of Daudenong (Victoria), and obtained for it the length of 420 feet, with proportionate width; while Mr. G. Klein took the measurement of a eucalyptus on the Black Spur, ten miles distant from Healesville, 480 feet high. . . . It is not at all likely that in these isolated inquiries chance has led to the really highest trees, which the most secluded and the least accessible spots may still conceal. It seems, however, almost beyond dispute that the trees of Australia rival in length, though evidently not in thickness, even the renowned forest-giants of California, *Sequoia Wellingtonia*, the highest of which, as far as the writer is aware, rises, in their favorite haunts at the Sierra Nevada, to about 450 feet. . . . Thus to Victorian trees the palm must be conceded for elevation."—*Mossman's Origin of the Seasons*, p. 367.

3. *Scientific Collections of Dr. Shumard.*—We would call attention to an advertisement of the library, minerals and fossils of the late Dr. B. F. Shumard of St. Louis. Dr. Shumard was engaged in various geological surveys, and his collections are of great value.

OBITUARY.

Dr. B. F. Shumard, died at St. Louis on the 14th of April, where he has resided for the last sixteen years. We are indebted to Dr. A. Litton for the following brief sketch of his life.

The doctor was a man of science in the highest sense of the term. He loved it, lived for it, devoted himself entirely to its pursuits, and in the prosecution of his favorite study contributed more perhaps than any man now living, to the revelation of the immense resources of the State of Missouri. As a scientific man, his fame was wide-spread, not only in this country, but in Europe. He was President of the St. Louis Academy of Science, and a corresponding member of the Geological Society of London, of the Geological Society of France, of the "Imperial Society of Vienna," of the "Imperial Geological Society of Hermstadt," and of the "Academy of Science" of Philadelphia, of California, of Cincinnati, of New Orleans, and of innumerable other similar societies,

which thus recognized his services to science. As a paleontologist he held a high rank, as his numerous published contributions amply attest. He has been in a declining state of health for about a year, having suffered from hemorrhage of the lungs. A few weeks since he started for New Orleans with a view of benefitting his health, and was on board the ill-fated steamer Ruth when destroyed by fire, and having to walk a long distance, the exertion proved too much for his emaciated frame. He went on to New Orleans, and returned to St. Louis two weeks ago last Monday; from which time he passed into a rapid decline, being conscious from the first that he could not recover.

Dr. Shumard was born at Lancaster, Pennsylvania, on the 24th of November, 1820, and was, consequently, in his 49th year. His father was a merchant, but he inherited his scientific tastes from his maternal grandfather, Mr. Getz, well known as an inventor, and the maker of delicate scales used in the Philadelphia mint. His father afterward moved to Cincinnati, and while living there Dr. Shumard graduated at Oxford, Ohio; returning to Philadelphia, he went through one course in the medical college of that city. His father then moved to Louisville, Kentucky, where young Shumard completed his medical studies in 1846. He then practiced for a short time in one of the interior towns of Kentucky, but subsequently removed to Louisville, where he devoted his leisure to the study of the fossils and shells in the adjacent country. His collection of organic remains was visited by Sir Charles Lyell and Mr. Edward DeVerneuil, when those distinguished savans were in Louisville, and the last named manifested his appreciation by the presentation of his great work on the Geology of Russia.

He was then appointed by Dr. David Dale Owen as assistant geologist in the U. S. Government Survey of Iowa, Wisconsin and Minnesota, for which he had been commissioned by the national government in 1846. He remained in that survey until the fall of 1856. The published reports of this important survey, in which Dr. Shumard took so prominent a part, will remain monuments of the industry, acquirements and ability of their author.

Besides his share in the publication of the reports, Dr. Shumard published a monograph, entitled "Contributions to the Geology of Kentucky," which abounded in original observations and made his name familiar to European geologists.

In 1850, Dr. Shumard was appointed by Dr. John Evans, to aid him in a geological reconnoissance of the territory of Oregon of which he prepared the paleontological report. He spent eighteen months in Oregon and returned to Louisville in 1852, where he occupied nearly a year in making out the reports on paleontology for his brother, Dr. George Getz Shumard, who was employed under Capt. R. B. Marcy, in the Red River exploration.

In 1853 Dr. Shumard came to St. Louis and was appointed Assistant Geologist and Paleontologist of the Missouri Geological Survey, under Prof. Swallow. He labored here until the summer of 1858, when he was appointed State Geologist for Texas, and made a reconnoissance of almost the entire eastern and middle por-

tions of that State, and had just got his specimens collected and arranged, when the war broke out, and he returned to St. Louis. In the survey of Texas he found within the limits of that State the most complete series of geological formations to be found in any State in the Union, ranging as they do from the oldest paleozoic strata, to the latest tertiary, and presenting an aggregate thickness, estimated at not less than ten thousand feet. He succeeded in rescuing his library from Austin at the end of the war, but never returned to prosecute the survey. His extensive collection of specimens is at the Bonham Female Seminary, where it was his intention to have it arranged and labeled under his supervision for the benefit of the people of St. Louis.

Doctor Shumard leaves a wife, and two daughters, one nine and the other four years old.

J. Beete Jukes, the accomplished head of the geological survey of Ireland, and Professor of Geology in the Royal College of Science, died at Dublin on the 29th of July last, aged 58 years. We cite the following notice of this able geologist from the Athenæum of August 14th.

Joseph Beete Jukes was an Englishman. For the last nineteen years he had been on the Irish Surveys. Prof. Jukes graduated at St. John's College, Cambridge, in 1836. He studied geology under Sedgwicke, of whom he was a favorite pupil. After he left college he sailed to and explored the north coast of Australia on board H. M. S. Fly, to which he was appointed as Naturalist. Subsequently he surveyed the island of Newfoundland. After his return from that country he joined the English survey under Sir H. De La Beche, when Mr. Jukes examined some of the most intricate parts of the geology of North Wales. Later he minutely worked out the South Staffordshire coal-field, and wrote a description of it, which was published among the Memoirs of the Geological Survey. In 1850 Prof. Jukes was appointed to the directorship of the Irish branch of the Survey, and in 1853 was elected a Fellow of the Royal Society. The book by which his name is best known is his 'Student's Manual of Geology.' His style as a writer is vigorous, clear and simple,—an exact portrait of the man himself, who by nature was open, straightforward and upright. As a field-geologist few could surpass him; in a moment grasping the key to a country, and being able to explain what others had puzzled over for months. None could generalize as he could; at the same time he did not despise details. He worked out each spot of country with minuteness. Under his acute supervision the igneous rocks of Ireland have been divided up and classified; and if his life had been spared for a few years longer he would have advanced our knowledge of that part of geology, and raised us to an equality with our brethren on the continent. His vigorous mind grasped the geology of Devonshire; and although few yet accept his solution, the final acceptance is only a question of time. His place on the Irish Geological Survey cannot easily be filled, more especially as the solutions of some difficult problems still remain.

V. MISCELLANEOUS BIBLIOGRAPHY.

1. *Machinery and processes of the Industrial Arts, and Apparatus of the Exact Sciences;* by FREDERICK A. P. BARNARD, LL.D., U. States Commissioner, Paris Universal Exposition, 1867. Washington: Government Printing Office, 1869. 8vo, pp. 669.—This is an extremely valuable memoir upon a great number of important topics connected with the Industrial Arts and the applications of mechanical and physical principles, as these were illustrated in the French Exhibition of 1867. These are considered in a systematic and exhaustive manner, in fourteen chapters, of which the general headings are: I. The relation of invention to industrial progress, pp. 1–25; II. Motors, pp. 25–127; III. Transmission of force, pp. 128–150; IV. Accumulation of force, pp. 151–161; V. Measure of force, pp. 162–168; VI. Direct applications of force, pp. 169–218; VII. Meters for liquids and gas; Boiler feeders, pp. 219–236; VIII. Machines and mechanical apparatus designed for special purposes, pp. 237–280; IX. Processes and products, pp. 281–332; X. Diving and Respiratory apparatus, pp. 332–346; XI. Improvements in the application of cold, pp. 346–360; XII. Artificial production of cold, pp. 361–402; XIII. Light-house illumination, pp. 403–416; XIV. Printing and the graphic arts, pp. 417–468. Under each of these general heads we find grouped a great number of most interesting and important matters, about many of which it is impossible to find elsewhere, if at all, so clear and exact statements. The mere enumeration of the topics thus discussed would fill several pages of this Journal.

The just claims of American skill and science are fully stated, with occasional reclamations, among which we are glad to find under chapter XII, a full recognition of Prof. Alexander C. Twining's American Ice Machine of 1850, which is unquestionably the progenitor of all similar machines, and which has been most shamelessly pirated and appropriated by European inventors. In concluding his account of Prof. Twining's apparatus, Dr. Barnard adds—"It cannot be too much regretted that an invention of so much merit and importance, and of which the soundness and commercial value had been so fully demonstrated, both theoretically and experimentally, should, through the apathy or timidity of capitalists, have been permitted to be neglected in the country in which it originated, till foreign enterprize had seized upon it, and developed it into a great industry."

This Report is illustrated by well-executed wood cuts of the most important forms of apparatus discovered, 154 in number, and is correctly and handsomely printed, under the supervision of Prof. W. P. Blake, charged with editing the Reports of the United States Commissioners of the Paris Exposition of 1867.

2. *Proceedings of the American Association for the Advancement of Science. Seventeenth Meeting, held at Chicago, Illinois,* August, 1868. Cambridge: Published by Joseph Lovering. 1869. 372 pp. 8vo.—This volume, elegantly printed at the Essex Institute Press, embraces twenty-six papers on mathematics, physics

and chemistry, and twelve papers on natural history, forming together only about one-fourth part of the papers communicated at Chicago; of the remainder, one hundred and six are given by title only. The address in commemoration of ALEXANDER DALLAS BACHE, by Dr. B. A. GOULD, followed by a list of his published works and the address of Dr. BARNARD, Ex-President of the Association, occupy the first one hundred pages of this volume and would alone give it a character of permanent value.

Inaugural Report of the Director of the Cincinnati Observatory, 30th June, 1868. Annual Report of the Director, 1st May, 1869. 48 pp. 8vo.

First Annual Report of the Trustees of the Peabody Academy of Science. January, 1869. 104 pp. 8vo. Salem. 1869.

First Annual Report upon the Geology and Mineralogy of the State of New Hampshire; by C. H. Hitchcock, State Geologist and Hall Professor of Geology and Mineralogy in Dartmouth College. 36 pp. 8vo.

Prodromus of a study of N. A. Fresh-water Algæ, by Dr. H. C. Wood, Jr. (Proc. Phil. Soc. Philad., vol. xi.) 28 pp. 8vo.

Nature: An illustrated Journal of Science. This new scientific journal, a weekly of 24 pp., the first No. of which is to appear in October, has among its pledged contributors the most eminent physicists, chemists, and naturalists of Great Britain. Macmillan & Co., London, are the publishers.

PROCEEDINGS ACAD. NAT. SCI., PHILADELPHIA, Nos. 3 to 6, June to Dec., 1868.—p. 153, Variations of Epigæa repens; *T. Meehan.*—p. 156, Monœcism of Luzula campestris; *T. Meehan.*—p. 157, Fresh-water origin of certain deposits of Sands and Clays in west New Jersey; *E. D. Cope.*—p. 159, Remarks on remains of Extinct Cetacea, etc; *E. D. Cope.*—p. 160, Descriptions of seven new species of Unio from North Carolina; *I. Lea.*—p. 161, Description of two new species of Unionidæ from Equador; *I. Lea.*—p. 162, Descriptions of Unionidæ from the Lower Cretaceous Formation of New Jersey; *I. Lea.*—p. 165, A Sketch of the Natural Order Liliaceæ, as represented in the Flora of the states of Oregon and Cal.; *A. Wood.*—p. 174, Notice of some Vertebrate Remains from Harden Co., Texas; *J. Leidy.*—p. 177, Indication of Elotherium in California; *J. Leidy.*—p. 177, Notice of Reptilian Remains from Nevada; *J. Leidy.*—p. 178, Notice of Vertebrate Remains from the West Indian Is.; *J. Leidy.*—p. 181, Remarks on Leaves of Coniferæ; *T. Meehan.*—p. 183, Mitchella repens, a dicœcious plant; *T. Meehan.*—p. 184, Second contribution to the History of the Vertebrata of the Miocene period of the U. S.; *E. D. Cope.*—p. 195, Notice of some remains of Horses; *J. Leidy.*—p. 196, Notice of some extinct Cetaceans; *J. Leidy.*—p. 197, Remarks on a jaw fragment of Megalosaurus; *J. Leidy.*—p. 200, Remarks on Conosaurus of Gibbes; *J. Leidy.*—p. 203, The Crocodilian genus Perosuchus; *E. D. Cope.*—p. 205, Notice of American species of Ptychodus; *J. Leidy.*—p. 208, Synopsis of the Extinct Batrachia of North America; *E. D. Cope.*—p. 221, Agaphelus, a genus of toothless Cetacea; *E. D. Cope.*—p. 227, Occurrence of Cupriferous Ores in Texas; *F. A. Genth.*—p. 229, Notice of some American Leeches; *J. Leidy.*—p. 230, Notice of some remains of extinct Pachyderms; *J. Leidy.*—p. 233, Some Cretaceous Reptilia; *E. D. Cope.*—p. 242, The Origin of Genera; *E. D. Cope.*—p. 300, Variations in Taxodium and Pinus; *T. Meehan.*—p. 303, Remarks on the Geology and Mineralogy of Venezuela; *R. P. Stevens.*—p. 305, Sixth Contribution to the Herpetology of Tropical America; *E. D. Cope.*—p. 313, Observations on some extinct Reptiles; *E. D. Cope.*—p. 314, Fruiting of Wisteria; *T. Meehan.*—p. 315, Notice of extinct Insectivora from Dakota; *J. Leidy.*—p. 316, Observations on Reptiles of the Old World, Art. 2; *E. D. Cope.*—p. 323, Notes on some points in the Structure and Habits of the Palæozoic Crinoidea; *F. B. Meek & A. H. Worthen.*—p. 334, Seed Vessels of Forsythia; *T. Meehan.*—p. 335, Remarks on Carboniferous Crinoidea, with descriptions of new Genera and Species of the same, and of one Echinoid; *F. B. Meek & A. H. Worthen.*—p. 359, Descriptions of seven new species of American Birds; *G. N. Lawrence.*—p. 361, Analytical table of the species of Baridius inhabiting the U. S.; *J. L. Le Conte.*—p. 365, Gyrinidæ of America north of Mexico; *J. L. Le Conte.*—p. 373, Species of Agonoderus, Bradycellus and Stenolophus inhabiting America north of Mexico; *J. L. Le Conte.*—p. 383, Annual Reports, etc.